THE HOME TEACHER

A CYCLOPÆDIA OF SELF-INSTRUCTION

EDITED BY

SAMUEL NEIL
Author of "Culture and Self-Culture" "The Art of Reasoning"
Editor of "The Cyclopædia of History" &c.

ILLUSTRATED WITH NUMEROUS ENGRAVINGS AND MAPS

DIVISIONAL-VOLUME I

LONDON
THE GRESHAM PUBLISHING CO.
34 SOUTHAMPTON STREET, STRAND

PREFACE.

Our age is astir with educational activity and intellectual aspiration. By the acquisition of knowledge man's wants are satisfied, his pleasures enhanced, and his power increased. Science is the servant of society. Our knowledge of nature is the measure of our dominion over things; or, as Bacon has expressed it, "Human knowledge and human power coincide." Power is ability to do; but ability implies knowledge, and knowledge presupposes study. The reign of man in the earth, and over the products and creatures of the earth, depends therefore on his intellectual superiority.

Education is the science and art of opening the mind to the reception of knowledge, stimulating it to exercise its faculties, and training it to reach forward to new efforts after fresh acquirements by persevering skill and with practised industry. The mind is rather an instrument for investigation than a storehouse of accepted results. These are too often a mere burden on the memory, seldom the assimilated gains of an active intellect, nourishing itself with attained truth.

Technical training will impart dexterity in those manipulations of art, manufacture, or calculation which require frequency of repetition and demand sameness of process; but for the higher purposes and pursuits of human life the giving of a true insight into the nature of the operations employed, the means by which the processes are wrought out, and the reasons on which results depend, is in the long run a far more valuable and effective mode of culture. All experiences, whether of science or of trade, mould themselves into laws which rule over every operation they involve. He who best understands all that is known and knowable regarding study or process is most master of all that can be accomplished in the branch of effort which engages him. The capacity to comprehend the *whys* and *wherefores* of our experiences and their results is improved by assiduous mental culture.

Education induces men to take pains to understand. It habituates to thoughtfulness and investigation. It adds a pleasant seeing to the eye. The causes and reasons of things and their phenomena are seen through what meets the view. This is the education that communicates power. The knowledge it gives is not mere acquisition, but development. It is a liberal instead of a restricted education. It is self-augmenting. It does not rest in what is learned, but aims at earning all that can be gained by industry and effort. Such education is never finished It is ever-aspiring, and only now attains that it may hereafter by more earnest endeavour make new successes its own. The education of the school closes, but the culture of the human mind is ever renewed and ceaseless.

To men who possess this aspiring frame of mind progress is always pleasant, and those who feel such promptings eagerly seek aid and means. Everything that promises help is to them a delight, and hope is constantly exciting them to fresh achievements. They are not satisfied with the mere bread-winning knowledge required to fit them for gaining a livelihood—though they never neglect or despise that. They recognize themselves as beings to whom intelligence has been given that they may learn and rejoice in what they know. They see all nature as a book which may be read by the wise, and a treasure-store which may be used by the daring. They look on the past as the long lesson of experience written that they may be the better for it; on society as a living teacher of many secrets; on labour not merely as the taskwork of life's day, but as the exercise of their skill; on art as the repository of serene enjoyments, literature as the highest intellectual companionship, and science as the record of man's discoveries in the exploration of nature.

Books are the keys to knowledge. They are the "Interpreter's House" for humanity. To him who reads, all the ways of wisdom are free and open; therein he may journey as he will. He is a freeholder of earth and sky, and may gather knowledge wherever he chooses. Science and art, history and politics, invention and industry, air and ocean, bird, fish, and beast, are his servants. He has acquired power—the power of cultured mind. Things cease to govern him; he governs things. He who has acquired knowledge possesses the sceptre over earth, to cultivate and modify it; over the sea, to rule and to traverse it; over the sky, to make it tell him of times and seasons, and indicate storm and calm; over air, to secure its services; over living creatures to enforce submission and docility; over animals and plants, to alter, change, employ, and enjoy them. Intellect is the sovereign of the universe.

Books are the common wealth of the world. They make their writers ubiquitous; they introduce to us in their best estate the men who know what we want to

understand. They are minds enfranchised from the trammels of time and space, who visit us in palpable embodiment, and tell us what our souls most long to know. Homer has, as Plato remarks, well stated the advantage of inquiry and communication:—

> "Through mutual intercourse and mutual aid,
> Great deeds are done and great discoveries made;
> The wise new wisdom on the wise bestow,
> Whilst the lone thinker's thoughts come slight and slow."

Books are intellectual companions and teachers, and whosoever uses them rightly is a good student. To know the proper use of books is one of the most necessary acquisitions we can make. To read is an accomplishment of high value; to read intelligently and receptively is peculiarly advantageous; to read sympathetically, assimilatingly, is a great benefit and a lasting joy. Reading should be choice in quality—only the best books being selected; it ought to be regulated in quantity, so that the books used may be fully and deliberately mastered; and it should be judicious in its mode—that is, with attention, consideration, and all the faculties of thought and memory active. The intensity with which our minds are concentrated on what we read is, in general, the measure of the good we get from reading as a study. The proper aim of studious reading is to inform the intellect, and increase our knowledge of facts and the laws which regulate them. It supplies the materials out of which the intellect is to elaborate knowledge and wisdom. Profitable reading is that sort which compels us to think while reading, and impels us to reflective continuance of thinking afterwards. It supplies us with information on which we may think, and with such impressive and suggestive statements of it as interest and captivate. Thus reading becomes one of the best agencies in self-culture. It stirs the intellect and spurs the will; it furnishes the memory and stores the imagination; it provides the material for thought, and places before our minds the ideas which have been excited by it in the minds of others.

Of the books we read for instruction, not only the kind and quality of the matter and the range and value of the subjects, but their vital interest and intellectual attractiveness, are important. They should contain correctly stated and well assorted facts; a store of varied and trustworthy information; and not merely from the nature of their subjects, but the method of their treatment and the excellence of their matter, they should have power to inspire enthusiasm and satisfy curiosity.

Books are numerous, and one may be surrounded with libraries of them without being wise—if they are not well chosen. It is not the man of many books who is wisest. It is he who uses what he has the best—provided his choice has been wisely guided at the first. "Beware of the man of one book," who knows it thoroughly because he has read it often and thoughtfully. He is well informed so far as it goes. He is not overmastered by his book, but has mastered it. It is incorporate with himself, and is not knowledge only, but wisdom.

To those to whom the possession or perusal of few books is possible, we proffer in this work a condensed library of carefully selected and widely varied matter. It is intended to be a supplement to general school teaching, designed to satisfy the desire for knowledge which education has awakened like an appetite, and to communicate as large a portion of information as the necessities of our times make absolutely essential to occupying the position of well-informed persons in ordinary social life. It does not consist of hasty compilations, but of carefully prepared treatises, which can always be kept ready at hand to be made use of when required, either for regular study or casual consultation. It contains knowledge suitable for all readers seeking profitable and interesting occupation for their leisure, and students desirous of engaging in sedulous self-culture—useful to the latter for its large aggregate of choice matter stored, preserved, and readily available in it; and acceptable to the former for its abundant variety, popularity of treatment, and clear conciseness of statement. It will be found to supply within moderate limits, and at small cost, a very extensive cyclopædia of self-culture; and it is hoped will prove a pure source of intellectual enjoyment, a sure means of advancing personal happiness, and a successful endeavour to secure for its readers not only improvement of mind, but the means of qualifying them for the attainment of success in the pursuits and professions of life.

CONTENTS

BOOK-KEEPING

BOTANY

CHEMISTRY

DRAWING

ENGLISH GRAMMAR AND COMPOSITION

ENGLISH LITERATURE

FRENCH LANGUAGE

FRENCH LITERATURE

GEOGRAPHY

GEOLOGY

PHYSIOLOGY

SHORTHAND

TRIGONOMETRY

ATHLETIC SPORTS AND PASTIMES

A SYSTEM OF PHYSICAL EDUCATION

LIST OF PLATES

VOLUME I

VOLUME II

VOLUME III

VOLUME IV

VOLUME V

THE

HOME TEACHER:

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ENGLISH LITERATURE.—CHAPTER I.

INTRODUCTION.

LITERATURE is thought made visible. In words exquisitely wrought it immortalizes wisdom. The written outlives and outshines the spoken word. Speech, which is the interpreter of the inner life, sparkles, delights, and fades. Literature preserves and re-embodies it; and the music of wisdom is enshrined in its written characters. Books are the treasuries of mind. Genius, love, and intelligence store up their best and choicest gains for us in them. "A good book," as Milton says, "is the precious life-blood of a master-spirit, embalmed and treasured up to a life beyond life." Literature provides for us information on every subject, and offers help in each department of life. It packs up in the happiest form, and in the most attractive manner, the finest treasures of the spirit. Thought after thought is photographed upon the pages of books, and all ages are thus illuminated for us. Instruction and pleasure are combined for the delight of the heart and the brightening of the mind. Genius glows through the fully furnished libraries of all times and lands, and glorifies the reader's intellect by the interfusion of man's best thoughts with his daily cares. The light of the soul through literature gives its gladness to grave and gay. Science and song, person and passion, nature and man, fact and fiction, experience and expectation, earth and eternity, are all wedded into oneness in the indissoluble relationships of literature. By it companionship in thought and communion of heart are made possible, though ages intervene or oceans divide. While it animates, exalts, cheers, clears, and cultures the spirit of the thinker, it guides, informs, blesses, invigorates, and gladdens the soul of the reader. This inheritance of wisdom—the divinest riches in the possession of man—communicated to us in books, is one of our gravest responsibilities and choicest blessings. It has rejoiced the past to bequeath to us the finest, rarest, and most precious of the possibilities they possessed in the productions they have left us. "The soul of literature," as Henry Morley puts it, "is the soul of man at work;" and in its results it presents to us the concentrated essence of a nation's most vital and influential minds. Therein there is garnered the ripest and most valued of the fruits of the tree of human life. Smiles greet us, passions thrill us, tears glisten for us, experience crystallizes into lucidity, and wisdom condenses its lambency for us in the elaborated thought which we call literature. For not all that is (or may be) written is literature, though it is expressed in letters. Time, taste, criticism, interest, and necessity sift all registered thought and every literary product, and "decay's effacing fingers" pass over much recorded incident in life and letters, and make themselves felt. The day-book, the ledger, the minute-book, and the order-book may, when put into the crucible of genius, yield the gold dust of truth, and the contents of their leaves may be transformed by might of mind into "The Wealth of Nations"—"as the leaves of the mulberry tree are converted into satin." Literature, while it never neglects the raw material on which the spirit of man may work, regards as its special stock the finished product and result of mental activity. Industry, judgment, and invention; memory, imagination, and reason; experience, event, and hope; act, custom, and accident, may all be embraced in letters; but, as a general rule, literature relishes what it lays up in its archives all the better in proportion to the skill employed in the collection, arrangement, and attractiveness of the matter brought into its storehouses; and welcomes most gladly, as well as speaks most fondly of, those works in which "sense perfects grace, and grace enlivens sense."

Every literature has its special character and peculiarities. Each is racy of the soil, full of the history, and marked by the circumstances of the nation among whom it has its birth. English literature is notably the literature of individuality and independence. It is the whole national culture and personal thought of the people fashioned into visibility, and aglow with the very vigour of freedom. It is genial, many-sided, and widely sympathetic; it embodies and contains wisdom concerning the loftiest truths, as well as knowledge, shrewd and solid, for the everyday purposes of life. Its hold on reality is firm and fast, and its capacity for expressing the highest ideality is great and true; it is irrepressibly temporal yet irresistibly spiritual, and so is a mirror of all being. It is a finely interwoven tissue of fact, feeling, and thought. It embalms experience and enfranchises fancy. It is not an abstract thing, but the abstract of man thinking—the inner man represented to the outward view—man self-revealed. It is, on the whole, honest, earnest, grave, and brave; but it is also humorous and cheerful. It shows that those who formed it could not only inquire, analyze, define, but dine, desire, and do. It is human and humane, yet national—a picture of the mind of man, with all his individual peculiarities of genius, as influenced by history and circumstance. The human life of men breathed out in words—the best utterances of the best minds of a nation whose deeds are recorded in history, whose industries and interests have developed through combined activity, and whose heart and

fancy have been stirred by similar patriotic enthusiasms—is national literature.

The speech of a people is influenced by their history. Migrations and fusions of races result in changes in forms of life and of language. Diverse efforts are made at intercommunication, and gradually there arises a common usable medium for the interchange of thought. The older folk-talk still circulates round the hearth and on the farm or in the field; but, in the market, in social intercourse, or in civic meeting, the language of neighbours, co-traders, and kindred, shapes itself into intelligibility and pleasantness. Such a fusion of races, and such an interfusion of languages, is inevitable where there are great historic movements, invasions, conflicts, new groupings and regroupings of men. In Britain speech is full of historic lore; its words bear the stamp of incident and change; and the books composed in the English language wear the impress of nationality and independence.

The first beginnings of a literature are not easily traced and determined. The wit of man must always have worked outward through speech to affect his fellow. Education must in early times have aimed at power of speech, bread-winning, and fighting. The instructors of the primitive dwellers in Britain, when history dawns upon our island-home, were Druids. But they forbade the committal to writing of the tasks they taught; they therefore hold no place as a literary guild. Ireland was probably first peopled by Celts from Spain. These rapidly spread to the Western Islands and the Scottish Highlands, and to Wales. But another stream of immigrants from mid-Gaul had entered South-eastern Britain; and they likewise strove to possess the land. Bread-winning then depended on power to fight. When fight was impossible, speech became the agent of peace, treaty, and compact. Admixture of race and dialect followed; and, by constant increase of entrants from the continental coasts, new urgency arose for the possessors to maintain their right and sustain their claims to dwell in this land of their adoption. Druid and bard sang. Celt and Gael and continental colonist contrived to fuse themselves into tribes. Thus, when Cæsar came and conquered, they had polity and speech among them, life customs, and social usages, communities, and laws. In the flux and reflux of events these people had acquired common interests, pursuits, and aims. Cæsar's invasion and the Roman dominion welded them, by oppression, into hardier resisting masses. Their speech, as an ineradicable possession, became more highly prized; and the songs which were sung in it, in secrecy, gained an added sweetness to the heart, because they were peculiar to themselves. Though therefore, with quick wit, they learned the Roman language, they gave rein to their imagination in their native tongue, and poetry poured itself forth profusely. The outlawed speech was nourished in moorland hut and woodland shed. Latin was the speech of outward life. The heart and hearth had a language of their own. It was traditional, not written; hence its easy, short, alliterative lines, its intertextured vocal concords—those aids to memory and charms to mind.

English literature is, as Lord Macaulay said, "the most splendid and the most durable of the glories of England." The people of Britain have thought and wrought and written more continuously, and to greater purpose, than any of the historic races of the earth. Among the nations of civilized antiquity, the literature of Greece is ever-duringly grand; but though it matured early, and ripened into exquisite deliciousness, it quickly faded at the rise of Roman power. Latin was rude in its early stages, and in its later borrowed and imitative; only in the Augustan age was it reflective of Roman masterfulness and magnificence—great, elaborate, and native. Hebrew holds a unique place for vitality, vigour, and universality of influence among the literatures of the globe; yet we have it only in fragments, and in the filtration of its spirit into the minds of all subsequent peoples on the earth. A great interval elapsed between the shaping of the German speech and its real and effective productiveness as literature, though now it is widespread, copious, and manifold. In Italy and in Spain, after a brief period of profuse Romanic outgrowth, the sap suddenly dried up, and only in recent times have these lands brightened the human mind with evidences of revival, rejuvenescence, and value. France, with most brilliant versatility and almost too florid a luxuriance, has given a graceful and plenteous harvest of thought-fruits to the nations. But in its bullion-masses, if not in the delicate, quaint, and deft coinages and jewelry into which it has been carved, chased, or cast, Britain outvies all literatures in worth and excellence, continuity and variety. It is a happy quality of literature that it can become—because it is composed in the common speech of the people—the common intellectual freehold of the entire community of those who know the English language, a language now more widely diffused throughout all the habitable regions of the earth than any tongue having interest for man.

ANGLO-SAXON ENGLISH.

No modern language enshrines a literature so ancient as England's. In the tongue now spoken all over "Greater Britain" the rude forefathers of the British race uttered their thoughts and expressed their wants nearly fourteen centuries ago. During its growth it has assimilated much, but the life which appropriated the nourishment brought within its reach was English. Celts and Teutons, under stress of circumstance, migrated to our land, and spread inland and upland over the country. From the lower course of the Elbe they brought healthy bodies, active minds, enterprising spirits, and they did not leave their gleemen behind them. These ministrants of joy brought the charm of song with them, and long before England was consolidated into a nation English speech had an embodied literature. At first we had a living library of bards, who read forth from the archives of their minds and memories the quick and potent outcome of their spirits. And for a long time, when hearts were stirred and interests roused, the minstrel outpoured into the ear and soul the emotioned thought which throbbed in him and thrilled through them. Much of this was improvised and "perished in the using." Their songs had lyric fire, dramatic life, resonant effectiveness, but they passed away from recollection with the mind through which they were wafted. It was soon found that a great deal of this alliterative verse was too good to be lost. Some of it was written down, and tale and tradition were thus transformed into literature.

The memory of the minstrel was the library of the laity. The traditions of the tribes, the fierce feuds of families, the victories of vikings, the successes of septs, the valour of the brave, the passions of lovers, and the revenges of foes, became the topics of the ballad-monger's songs. They were composed with a view to recitation and musical repetition, and therefore they made much use of "apt alliteration's artful aid." The ear, not the eye, noted the assonances. These were arranged in regular recurrence thus: two of the chief words used in the first line of a couplet must begin with the same letter-sound, and that same letter-sound must form the initial of the first word in the second line on which the stress of the voice is planned to fall. Two rising and two falling inflections of the voice are essential to the formation of a perfect verse. The following quatrain from "Piers Ploughman" will illustrate this peculiarity:—

> "There *p*réached a *p*árdoner
> As he a *p*riest were;
> *B*rought forth many a *b*ull
> With many *b*ishop's seals."

These euphonic catches for the ear formed also cues for the memory, and while they displayed the composer's deftness, they supplied links of suggestion to the minstrel's memory. These graphic groupings of accentuated sounds gave grasp to the gleeman of the swing of the song. Finely articulated and artfully constructed as these alliterative poems were, they do not form literature. They were rather poetic oratory, storied songs enriched with rhetoric. When writing came into use, and reading reduced the need for recitation, literary forms of a freer sort became possible, and prose, for ordinary purposes, supplanted poetry. Choice artistry in words was not on that account neglected. The moulds of oral rhythm became the models of written verse, and the musical harmony of diction, in which poetry delighted, was wrought into more deliberate measures when writing placed before the eye the elements of pleasure to the ear. Composition grew less abrupt,

elliptical, and repetitive. Figures of speech were more accurately drawn, and the meaning was not so much mantled with the mists of metaphor as it had been when thought was orally expressed.

Poetry is the earliest form which literature takes. It is the making of thought articulate. The artistic employment of words commends itself to the brighter and better minds, and hence it is regarded as one of the prime delights of life. On "the mighty roll of books" which are the literature of England, the first place by right of originality and influence is due to "The Metrical Paraphrase of the Scriptures," by Caedmon (*Kaydmon*), a lay-brother monk of Whitby, under the Abbess Hilda, about 680 A.D., who—according to Bede—was called by a heavenly, though visionary, voice "to sing;" and under this impulse set, to the old music of the gleeman, the story of the Bible, in homely words for homely hearts to con. "He sang of earth's creation and the origin of the human race, and all the history of Genesis, of the exodus of Israel from Egypt and the entrance into the Land of Promise, of many other histories of Holy Writ—of our Lord's incarnation, passion, resurrection, and ascension into heaven—of the descent of the Holy Spirit and the teaching of the apostles. He also composed many verses on the terror of the judgment to come, of the fearful punishments of hell, and of the sweetness of the heavenly kingdom, besides many others on the loving-kindness and judgments of God, in all of which his care was to withdraw men from the love of wickedness, and to excite in them the love and understanding of well-doing." "For us," he sang, "it is very right that we praise God with our voice, [and] love in our souls the Warden of the heavens, the glorious Lord of Hosts. He is of all powers the Essence, the Chief of all his great creations, the Ruler-Almighty. There never was for him first beginning, nor has there been, nor cometh there now, any end to that eternal Lord; but his power is everlasting above heavenly thrones. With high majesty, faithful and firm, he rules the depths of the firmament that were set wide and far, for the children of glory—the Guardian of souls." In a single MS. a large fragment of religious poetry, answering fairly well to Bede's description, was found in the university library at Cambridge. It came into the hands of Francis Junius, who issued it in 1655. Some accept of this as Caedmon's poem, some doubt its being so, and some regard it as a later transcriber's version of that monk's attempt to bring to the hearts and hearths of the people, in their own tongue, the lessons of Christianity.

The first words of English literature are those of Scriptural faith; its next (if second it be), are those of heroism, adventure, and mystery. The "Beowulf" saga holds not without right a highly important place in both German and English literature. In it we have the story of (1) the adventures of Beowulf, king of the Jutes, son of Woden (as, of course, all these mythical heroes are), in his fight with Grendel the sea-monster ("whose cursed hide recketh not of weapons"), and with that fiend's mother; and (2) his deadly conflict in his old age with a huge fiery dragon, a sea-shore guardian of a mighty treasure hoard, which by his death he gains, not for himself, but for others—before he follows his forefathers to be "an earl of God." There appears to be good ground for believing that this poem was imported from Angeln by some of our Teutonic ancestors, and afterwards rendered into Anglo-Saxon * and recast in a Christian mould. This relic of antique time contains 6358 lines, of which the length and the rhythm vary—few having less than four syllables, two accented and two unaccented, and some having eight, nine, and even more, marked by accentuation, pause, or assonance of initial sounds. This is the old Teutonic metre, on which, with varying harmony, our early verse was formed.

Besides these early great poems we have snatches of song carried down with time's tide from these far-gone centuries. "The Gleeman's Song" supplies the first literary allusion to our Angeln progenitors while still resident in *Wistla-wudu* (the woodlands of the Vistula). This traveller's song, in 284 lines, tells of a minstrel's wanderings with much geographical detail but little plot-interest. "The Fight of Finnisburg" is apparently only a fragment of a larger poem on "The Perils of Finne's Offspring," in which the flush and rush of a hero's blood are seen and felt. "The Song of Deor the Bard," preserved in the Exeter Book, † shows how he like Weland (the armourer), "knew in himself the worm of exile," because a "song-crafty man had obtained the land-right" which had aforetime been his. The same Exeter Book contains hymns to the Saviour, the Virgin, and the Trinity; songs on the nativity, the ascension, and the harrowing of hell; poems on the day of judgment, the crucifixion, and the state of souls after death; anthems of thanks and praise; a versified sermon; a metrical version of Felix's Latin "Legend of St. Guthlac," who stood firm amidst the terrors and temptations of fiends who plotted against him for his devotion to the Cross, till at last he was led lovingly by angels to the presence of God in the upper sky; and "The Legend of St. Juliana," who preserved her purity despite the guiles and wiles of Satan. This was written by Cynewulf, who, besides being the author of a series of poems on Christ, has in a dull, diffuse, didactic style sung the legend of St. Helen—"Elene," in 2648 lines, found in the Vercelli Book. ‡ In the same book was found "Andreas"—a poem in 3444 lines—which relates how St. Andrew, preaching in Achaia, was warned by "a voice from heaven" to go in aid of St. Matthew, then in great danger in Mermedonia. God and two angels are in a boat on the shore, and the saint embarks among other passengers whom they are to row across the sea. A storm rises, an animated conversation ensues, the tempest is lulled, the passengers fall asleep, and next morning St. Andrew, among the rest, awakes on the shore of Mermedonia. He proceeds to the castle where Matthew lay bound. The seven guards fall dead at his approach, the doors open, the saints embrace, St. Matthew and his companions in durance escape, and St. Andrew returns to the city. The cannibal Mermedonians, wishing a good breakfast, send for a fat prisoner, but find the castle empty. Being hungry, they cast lots who shall be eaten. The lot falls on a young man, swords are uplifted to slay him, but St. Andrew prays, and their weapons become soft as wax. Satan reveals the saint's presence, and the rabble seize and drag him over sharp rocks and rough roads. Each night his wounds heal, only to be next day renewed. After many miracles, his persecutors relent, repent, and are baptized. St. Andrew appoints Plato bishop over the Mermedonians, and, to their intense grief, departs from their coasts.

In addition to several other fragments and specimens of Anglo-Saxon verse, there is extant a portion of a fine poem on "Judith," founded on the record in the Apocrypha, but Teutonic rather than Jewish in colouring, full of spirit and worthy of note. It may be of date 1050 or so. The old tale of "Apollonius of Tyre," derived from the "Gesta Romanorum," which was so great a favourite with our ancestors, and on which Shakspeare's play of "Pericles" is founded, exists still and has been frequently reproduced. We may also refer to the song of "The Wonders of Creation"—the only known instance of a rhyming poem: it appears to be a paraphrastic extension of a passage in Job; and to an Anglo-Saxon version of the Psalms of David, of which Aldhelm is said to have translated from the fifty-first Psalm to the end. These, with a few other scraps and odds and ends, form almost all the poetical productions extant in the language used in Britain between the shaping of the national life and the era of the Norman Conquest.

* "Anglo-Saxon," we are aware, is a term of modern origin. Our forefathers called the speech they spoke *Ænglish.* "Anglo-Saxon," however, enables us to distinguish in our minds that elaborate and well-developed language used by the people and written by the learned prior to the period of the Norman Conquest, from that tongue which—though logically and etymologically the national language still—took new form (becoming a compound of many elements requiring fusion, both in vocabulary and syntax) as what we now call English.

† The Exeter Book is a collection of poems given by Leofric, bishop of Exeter (1046–73), to the cathedral library of his diocese. It contains the oldest collection of Anglo-Saxon poetry, and has been edited from the Codex still extant, in clearly written script, in Exeter.

‡ The Vercelli Book is a volume of Old English manuscripts discovered in the Milanese Monastery at Vercelli, in 1823, by Dr. F. Blume.

LATIN LITERATURE IN ENGLAND.

"Book language," as Latin, the language of the learned, was called, was never really the speech of the British. There were many works composed by Britons in Latin, which, though they belong rather to the literature of Europe than of England, kept up the continentalism of culture in this island. The thinkers of all lands formed a commonwealth of intellectual comrades who employed Latin as a form of speech universally known. The home-tongue was, however, not abandoned though the world-wide one was superadded. In the cloistral study the monk sought to express and conserve the precious pith of learning and literature to be found in the writings of the Christian brotherhoods of other lands and ages. So Theodore of Tarsus, archbishop of Canterbury, skilful in Greek and Latin, diffused wisdom and grace around. Abbot Adrian, African though he was by birth, was a "fountain of letters and river of arts in Britain." Aldhelm, a well-born poet and divine, first bishop of Sherborne, "unequalled as an inventor and singer in English verse," composed in Latin a "Treatise in Praise of Virginity," and in a thousand Latin hexameters explains "the Scripture use of the number seven," "the rules of Latin Prosody," and, as a piece of priestly pleasantry, supplies a "Collection of Enigmas," each intended to fasten in the mind some special information as to "science in common things." A few other Latin poems, and fourteen Latin letters, are also left us from this wise prelate's pen. Wilfrid, a noble of Bernicia and archbishop of York, a man of restless energy, was the subject of the first biography written in Britain. It was the work of his friend and disciple, Eddius Stephanus of Oundle. It was subsequently converted into hexameters by Fredegode, a monk of Dover. Our earliest autobiographer, or artist in autobiographic fiction, was Edwin of Worcester, founder of the monastery of Evesham (703 A.D.), of the foundation of which he also wrote an account. Adamnan, abbot of Iona, author of a "Life of St. Columba," composed—from information furnished by Arculf, a Frankish bishop—a pilgrims' guide to the Holy Land (*De Situ Terræ Sanctæ*); and Willibald, inspired by this book, made a palmer's journey to Jerusalem, of which, when bishop of Eichstadt, he dictated a record to a kinswoman, then a nun of Heidenheim. This is England's earliest book of travels.

The most able, versatile, and healthy-toned writer of Latin prose in these times was the Venerable Bede, who was, as he tells us, "born in the territory of the monastery of Peter and Paul at Wearmouth and Jarrow, and sent, at seven years of age, to be educated there by Abbot Benedict and Ceolfrid." The former—who had been a thane named Biscop—was an ardent seeker for knowledge, who brought all attainable book-treasures to Wearmouth; the latter was the first abbot of Jarrow. Bede condensed all the knowledge of his age into an encylopædic digest in his treatise "On the Nature of Things," a book which for a long time was England's compend of science. Tractates of an educational sort of all kinds flowed from his pen, while to promote the vigilant and unwearied daily study of the Scriptures, he arranged and harmonized all that had been wisely said by Bible commentators. He composed many exegetical treatises, a full martyrology, a large number of lives of saints and abbots, several expositions of the books of Scripture, besides homilies and hymns. Bede's "Ecclesiastical History" is for us really "The History of Britain" up to 731 A.D., and constitutes the first-born of the long series of histories in which our literature is so surpassingly rich.

Bede died at Jarrow, 26th May, 735 A.D. He was buried within the church; but a monk of Durham, Elfred, stole his bones thence, and laid them in Durham Cathedral beside those of St. Cuthbert. Fable says that the brother who had been chosen to write Bede's epitaph fell asleep, after having exhausted himself in striving to fill up his hexameter with a fitting epithet, and that an angel came and completed the task, writing the italicized title in the line—

"Hæc sunt in fossa, Bedæ *Venerabilis* ossa."
(In this grave are found indeed the bones o' the Venerable Bede.)

Though he wrote in Latin he was well versed in vernacular poetry, and even on his deathbed cast his thoughts into these English verses, which, as St. Cuthbert tells us, he uttered with great feeling:—

For tham neod-fere,	For than is needful,
Nenig wrytheth	No one is wiser
Thances snottra,	Thence out-going,
Thonne him thearf sy,	Before he departs hence.
To gehiggene	To consider
Ær his heonen-gange	Ere his hence-going
Hwet his gaste,	What his spirit,
Godes oththe yveles,	Of good or of evil,
Æfter deathe heonen	After its death
Demed wurthe.	May be deemed deserving.

Flaccus Albinus Alcuinus (whose Saxon name was Alcwin) was born in York in the year (735) of Bede's death. He was educated in the cloister school of his native city, and after accompanying his master Aelbert (afterwards primate of York) to Rome, he was appointed teacher of the same seminary. On his way to Rome, whither he went to bring the pallium from the Pope to Eanbald on his appointment to the archi-episcopate, he met Charlemagne at Pavia, and was invited to settle in his court. He consented, and in 782 Alcwin established at court a sort of association for the pursuit of the severer studies, and was recognized as the leader of the learned. On his retirement from court life in 796 to the Abbey of St. Martin, at Tours, he founded a school, whose fame rivalled those of Rome and Athens, and for this he provided an ample library, getting many books transcribed in England for it. His last years, full of infirmity and pain, he occupied in revising the Latin text of the Scriptures. He died at St. Martin's, 19th May, 804. His Latin composition is easy and flowing, though several unclassical peculiarities mark his style. His grammatical writings exercised great influence over the students of his day. In his dialectic he widens the common definition of logic into the discipline of the reasoning powers in inquiry, discrimination, and discussion, in order that they may be made efficient in distinguishing truth from error. His other prose writings are chiefly theological compilations intended for religious edification. In his Latin elegiacs, "De Rerum Humanarum Vicissitudine et Clade Lindisfarnensis Monasteri" (On the changeableness of human affairs and the disaster of the Lindisfarn Monastery—from the incursions of the Danes, 793 A.D.), as well as in his hexameter poem, "De Pontificibus et Sanctis Ecclesiæ Eboracensis" (On the bishops and saints of the Church of York), he uses the Latin language with vigour and skill, though he seldom produces felicities of expression or originalities of thought. His scholarship was wider than exact; but better even than being great, he was good.

Alfred the Great, youngest child of Ethelwulf and Osburga, born at Wantage, Berkshire, 848 A.D., was one of the most ardent and successful agents in the restoration of literary culture in England. He issued a circular letter to his bishops recommending them to translate useful books into Saxon, "that the youth of England may be grounded in letters, for they (he wisely said) cannot profit in any pursuit until they are well able to read their birth-tongue." His sympathies with learned men attracted many to his court, who aided him in his high aims. That his subjects might be instructed in the history of the past, he translated into the Saxon speech "The History of the World," composed at the suggestion of St. Augustine by Paulus Orosius of Tarragona. Alfred improved and adapted the materials as he proceeded, and enriched the book with additions on the geography of Europe and reports of the travels of Othere and Wulfstan in the Arctic Ocean and the Baltic. Orosius narrates, in what Lord Bacon calls a "watery" style, the course of events from the creation to 471 A.D. He designed to "assert eternal Providence, and justify the ways of God to man." To this—the favourite text-book of the middle ages—Alfred provided for the people a continuation, consisting of an abridged version of Bede's "Ecclesiastical History," then the best account of their own land which he could put into the possession of his countrymen. In his zeal for diffusing knowledge among his subjects he translated "The Consolations of Boethius"—"the masterpiece of the last man of genius produced by ancient Rome"—and the "Pastorals" of Pope

Gregory the Great, "on the care of the soul." A copy of this work was sent to each of Alfred's bishops, whose names were severally inserted in the translator's preface to the copy forwarded to each diocese. At Alfred's request, Waerferth, bishop of Worcester, abridged "The Dialogues" of the same pope. "The Soliloquies of St. Augustine," on faith, hope, charity, and truth, which is sometimes called the Anglo-Saxon Anthology, exist in a version which has been attributed to Alfred. A collection of Proverbs, translations of some of the Parables, and of "Æsop's Fables" are, to a certain extent, plausibly said to be his, and shortly before he died he had begun an Anglo-Saxon version of the Psalms. He tells us that in translating he "sometimes interprets word for word, and sometimes meaning for meaning," and as he proceeds he often inserts original matter. His translations are the most masterly and purest specimens of Anglo-Saxon we possess. His career as sovereign and scholar, statesman and legislator, reformer and philosopher, warrior and diplomatist, is one of wonder, when we know that the life he led was racked with chronic pain and tortured with political anxieties. His danger from the Danes, and his troubles from Athelney to Ethandune did not make him desist from his design of diffusing through his dominions as much useful knowledge as could be couched in Saxon speech. He died in 899.

Asser, a Welsh ecclesiastic, is reputedly the author of a biography of King Alfred. He had gone "from the western and remotest parts of Britain," St. Davids, to Dene in Sussex, on Alfred's invitation. At his court Asser, during part of the year, enjoyed intercourse with the king and acted as reader to him. About 893 he thought of compiling a history of Alfred's reign, but the work extant under his name as "De Rebus Gestis Ælfridi" is regarded as inauthentic. All therefore that is known of him is that he aided Alfred in his endeavours to provide for the diffusion of knowledge among the subjects of that sage sovereign, who sought to make all the free-born youths in his kingdom able to read English writing perfectly.

John Scotus Erigena (flourished 850), "the latest of the students of wisdom," was a Briton famous at the court schools of Charles the Bald. Of the place and date of his birth and of his parentage we know nothing. He had the practical Anglo-Saxon characteristic of knowing how to use his knowledge. He was quick-tempered and free of speech, but a miracle of thoroughly digested information and ingenious wit. Though, as his opponents called him, "a barbarian hailing from the extreme edge of the world," he understood Greek, and translated the works ascribed to Dionysius the Areopagite into Latin, and Maximus the Scholiast on those works. He was, as William of Malmesbury says, "a man of clear understanding and amazing eloquence." He was influenced by Plato, Aristotle, and Augustine, and was the earliest noteworthy scholastic philosopher. His "De Divisione Naturæ" was one of the most effective treatises on the thought of the middle ages, and originated that form of philosophy then called Realism. He was recalled to England by Alfred, and was, according to Roger of Hoveden, murdered by his pupils with their writing styles, as a heretic.

Ethelwold, "the benevolent bishop" and the "father of monks," was born about 923. He was ordained priest along with Dunstan, 947, and went with him to Glastonbury. In his anxiety for the promotion of learning he was about to pass over into France; but Dunstan conferred on him the Abbey of Abingdon, which was rebuilt 950, and consecrated him bishop of Winchester. He was an enthusiastic teacher, and was accustomed to translate orally into the Saxon tongue the contents of Latin books of information. He died 984. His translation of "St. Benedict's Rule of a Monastic Life," into Anglo-Saxon, is extant.

Dunstan was connected by birth with the Archbishop of Canterbury and the Bishop of Winchester. He was born at Glastonbury in 925, lived some time at court, fell in love, was restrained from marriage, took fever, recovered, and thereafter joined the church. He devoted himself to study and pious works. He was regarded as a saint, and was, as he believed, persecuted by demons. He was a tyrannous churchman, and when he had offended Edwy he retired to the monastery of St. Peter's at Ghent. Edgar recalled him, made him successively bishop of Worcester and of London, Archbishop of Canterbury, and prime minister. He was a painter, a musician, and an artist in metals. He was fond of the Anglo-Saxon songs and tales, and held that the study of the poets was required to improve the minds and polish the style of those who read them. He issued a copy of the Benedictine Rule, with an interlinear Anglo-Saxon version, and accompanied with a commentary.

Bridferth (flourished 980), one of the most eminent scholars, especially as a mathematician, in Britain. He had pursued his studies under Abbo of Fleury, in France, and passed as a monk from Thorney to being teacher in the Benedictine Abbey of Ramsey in Huntingdonshire. He took Bede's "De Natura Rerum" and "De Temporum Ratione" as his text-books. His "Commentaries" on these tractates exhibit a large amount of reading and thought. Mabillon attributes to him "The Life of Dunstan."

Aelfric "the Grammarian," son of an Earl of Kent, was the chief educationist in the diocese of Winchester. His "Glossary" is the earliest extant Latin-Saxon Dictionary. He translated the Latin grammars of Priscian and Donatus into the home-tongue, and himself brought out a grammar of Anglo-Saxon in Latin. He prepared Latin colloquies to elevate the instruction given in schools. He also produced versions of almost all the books of the Hebrew Scriptures into the lay-speech. His "Homilies," "Treatise on the Trinity," and other writings, were most effective in their day. As pupil in the monastic school at Abingdon, master in Winchester, abbot of Cerne in Dorsetshire, bishop of Wilton, and archbishop of Canterbury (995), he patriotically encouraged the revival of learning begun by Dunstan and Ethelwold.

THE ANGLO-SAXON CHRONICLE.

The Anglo-Saxon mind appears to have been "naturally inclined to poetry." Winifred, born at Crediton in Devonshire (607), afterwards named St. Boniface of Germany, wrote many letters, several sermons, some biographies, and nine enigmas (in verse) on the virtues. Acca not only collected in the bishopric of Hexham (709) "a most noble and ample library," and encouraged Bede to produce many books, but also cast his holy thoughts into Roman metres as hymns. Tatwine, a Worcestershire monk and archbishop of Canterbury (731–734), wrote Latin verses and composed enigmas. Cuthbert, archbishop of Canterbury (740–758), cultivated the muses. Ethelwolf, who was born about 770, wrote a metrical "History of the Abbots of Lindisfarn" (802–819), which has less merit as a Latin poem than as a historical document. Fredegode of Dover (flourished 956), at the request of Odo, archbishop of Canterbury, turned "The Life of Wilfrid," written in Latin prose by Eddius Stephanus, into hexameter verse. Wulfstan did the same office for Lanfred's book "On the Miracles of St. Swithin." Briestan's "Elegy on the Destruction of Croyland Abbey" has all, except a few lines, been lost. These, together with the punning imitations of the classical measures by Alcwin and Aldhelm, and the industriously pursued versifications of Bede, show that the spirit and art of poetry exerted a charm upon their heart and an influence on their lives.

"The Anglo-Saxon Chronicle"—the labour of many men through several centuries—is a national register of events. It is said to have been suggested by Alfred the Great, and to have been begun at Bishop Plegmund's instigation. It is, in its earlier portions, mainly an abstract of Bede's history. It opens with a concise account of Britain and of its invasion by Julius Cæsar, and carries on the record till the accession of Henry II. At first events are rapidly summarized by the compilers, but from Alfred's time the annals appear to be contemporary. It seems to have been prepared by a succession of general official editors, who were probably furnished by the scribes of several monasteries with their notes of the news in their districts. These each arranged, condensed, and redacted in his cell at Canterbury or Peterborough. Of this, when finished for the year, the several contributing monasteries appear to have been supplied with copies, which they engrossed in their own convent chronicle, and thus we have a connected national history of Britain from about 853 to 1154 A.D., with an introductory epitome of events in the preceding nine centuries. It was essentially the Anglo-Saxon year-

book of history compiled by acknowledged historiographers. It is national in spirit, and is composed in native Saxon, though towards its close the writers seem to have become less careful of purity of phraseology—following in these things, probably, the general habits of their age. This was the most sustained endeavour made to give perpetuity, in a literary form, to the Anglo-Saxon tongue. Though it was a book-language earlier than any other European speech, it was compelled to retire into provincialism before the power of Latin, the language of the church and of the science, history, and literature of Europe, which all men of culture read and wrote; and the advancing influence of Norman-French, which all courtiers used and favoured. Though the monks steadily kept up the writing of their "chronicle" in the native tongue; though the priests persistently preached in the vulgar folk-speech; though the populace sang their old ballads loudly in the streets and ale-houses; and industriously holy men composed biographies of the saints and translated the Gospels into the tongue the people knew—the power of the church and the charms of the court combined, led the cultured more and more from the use of the locally limited and fashion-proscribed tongue of the laity.

The Anglo-Saxon Chronicle enshrines many remarkable poems. Among these are the war-song of Brunanburgh—a spirited triumphant ode for the victory of Athelstan over the Danes, led by Olave from Ireland, and the Scots brought as allies by Constantine II. (937). Its author is unknown, but its merit and popularity secured for it a place amidst the prose of the national register of events. Again in 941 the Chronicle rhymes the success of Edmund in subduing Mercia, and regaining from the Danes the towns of Leicester, Lincoln, Nottingham, Stamford, and Derby. In 958 the accession of Edgar is recorded, and his reign is celebrated as one of peace and prosperity in verse; in 973 Edgar's anointment as king of Bath is metrically told; and in 975 two short yet diffuse elegiac poems narrate King Edgar's death. In the Chronicle of the same year a poetical denunciation of Ælfhere, who destroyed Ethelwolf's monasteries, occurs, and in 1002 a dozen lines of verse describe the misery inflicted on a town taken by the Danish rovers.

Besides these poems contained in the Anglo-Saxon Chronicle—to which, "putting aside," as Earle says, "the Hebrew annals, there is not anywhere known a series of early vernacular history comparable"—there exists a fragment of a long poem on a battle fought at Maldon in 994 between Byrhtnoth, an ealdorman of Essex, and the northern rulers, Justin and Guthmund, in which Byrhtnoth was defeated and slain. The latest specimen of Anglo-Saxon verse is also a fragment. It was found written on the margin of a volume of Homilies; the subject is "The Grave." In it Death speaks to man, saying:—

"For thee, ere ever thou wast born, an house was built; for thee, even ere thou camest forth from thy mother's womb, was there a mould shapen. Its height is not fixed, nor its depth settled, neither is it closed, till I—however long it may be—bring thee where thou shalt remain and measure thee thy length in earth-sods. Not loftily is thine house prepared. Not high is it, but low. When thou art therein the endways are low, the sideways are low. The roof full nigh thy breast is built; and so shalt thou dwell in thine earth-house—all acold, dim, and dark. . . . Doorless is thine house, and dull it is within; there art thou fast made prisoner, and Death holds the key thereof. Loathsome is this mould-home, and gruesome to dwell in; yet therein must thou make abode, and worms shall share its space with thee. Thus art thou lowly laid, and leavest thy friends; thou hast no friend who will come to thee, who shall ask how thine house suiteth thee, who shall ever open the door thereof and seek for thee, for soon therein thou becomest loathsome and woeful to look upon."

Was this song prophetic of the destiny of the literature of which it seems it is almost the last utterance? No! for into this old language "The Psalter" had been translated, and the story of the Four Gospels—"Tha Halgan Godspel on Englisc"—was preserved. In the language of the common folks, arranged for perusal on Sabbaths and holy days by the priests to the people, that book was provided for use in public worship which points to "the strait gate," entering through which "death is swallowed up in victory."

A considerable deal of Anglo-Saxon verse was written in the eleventh century. Leofric, to whom we owe the Exeter Book, produced well-reputed works which recorded the doughty deeds of the heroes of our early history. It is probable that the songs which enshrined the memory of the daring of "England's darling—Hereward, the last of the Saxons," were written by Leofric, who was his chaplain, and was one who knew the worth and felt the power of song. Among the royal authors of Anglo-Saxon verse in England, tradition includes the name of Canute the Dane. As he was going by boat to keep, at Ely, the Feast of the Purification of the Virgin (February 2), he looked up at the church, which rose from a rock near the river Ouse, and ordered the rowers to row gently towards the land, that he might hear the psalms the monks were singing. Then calling his companions about him, he bade them sing with him; and in the gladness of his heart, composed this little song in English:—

"Merrie sungen the muneches binnen Ely
Tha Cnut ching reuther by.
Rotheth cnites noer the land
And here ye thes muneches saeng."

(Merrily the monks in Ely sang
As Canute, the king, was sailing along;
Row gently, knights, row near the land
And list to these monks' choral song.)

"With other words" (says Thomas of Ely in his "Historia Ecclesiæ Eliensis," written about 1166, chap. xv.) "which follow, still publicly sung and remembered in proverbs." And so we find gospel and gleeman's song, traditional tale and holy hymn, passing through the land and forming the folk-literature of the age before printing had arisen to put the poet's verse, the historian's narrative, and the fictionist's story into the hands of the people of all lands and ranks, and to speed "the Book of Books" on its mission of mercy, to tell to all nations, as it did to the Saxons, in their own "tongues, the wonderful works of God."

Except through the Anglo-Saxon Chronicle and an epitome of the history of his native country composed (*circa* 930 A.D.), in exceedingly barbarous Latin, by Ethelwerd, an Oxford scholar, for the use of his cousin Matilda, the Emperor Otho's daughter, we have no means of gaining any historical information regarding the state and affairs of Saxon England from the home-born race. William of Malmesbury speaks of himself as "the first who, since Beda, has arranged a continuous history of the English." "For skill and judgment," he was, in Milton's opinion, "by far the best writer" of all our historians. He states that he traced his ancestry to both Norman and Saxon sources, and gives that as a reason for his impartiality as a historian. He was an enthusiast for books, an insatiable reader, and an indefatigable writer. In general he carefully distinguishes between what he derives from books, from trustworthy information, or from personal knowledge. He wrote many lives of the saints. His "De Gestis Pontificum" supplies accounts of the archbishops and bishops of the several English sees, of the events which occurred in their time, and of the great religious houses within their dioceses. In his "De Gestis Regum" he (1) epitomizes Anglo-Saxon history from the landing of Hengist and Horsa in Kent (449 A.D.), to the consolidation of the Heptarchy into the kingdom of England under Egbert (827 A.D.); (2) records the vicissitudes of the kingdom till the Conquest 1066; (3) supplies a narrative of the reign of William the Conqueror, 1087; (4) gives a brief account of William Rufus, 1100, and a copious report of the first Crusade; and (5) recounts the chief events of the first twenty years of the sovereignty of Henry I., to whose son, Robert of Gloucester, the work is dedicated. Under pressure from his patron he, under the title of "Historia Novella" resumed his task and brought down the record till 1142, breaking off in the middle of the civil war between Stephen and Matilda, with a promise to continue the telling of the story, "if by God's permission I shall ever learn the truth of it from those who were present" at the war. William of Malmesbury probably died while this conflict was raging. He is an industrious and candid investigator of traditions, statements, and reports, and "furnishes the best record of the political life of Anglo-Saxon England" from a contemporary pen.

HISTORY.—INTRODUCTORY.

"History," as Dr. Arnold defines it, "is the biography of nations." Its first and fundamental form is the Chronicle. There was a period in the past when all thought manifested itself in poetry. History then appeared as song. The epic presented itself to men as a record of events, and gathered the traditions of olden ages into the treasuries of literature. But registers of genealogies and ancestral tables of the members of the heroic families of early times, constitute the original germs and seeds of that which has attained to flower and fruit in history. It need scarcely be said that the narratives of experience of outward fact and incident imparted in genealogies and legendary chronicles supply little information, and that generally a considerable mass of fable mingles with the authentic matter they contain. In the mist of tradition many things glitter and glow with apparent splendour and glory which, when the sunlight of knowledge shines directly upon them and the mist has cleared away, are very far from being worthy of their renown. The men of the past and the occurrences which have taken place in a community, when writing has not brought to it the power of transmitting memorials of them from one age and country to another, pass like the views of a swiftly gliding panorama before the eyes, and leave as little trace behind them as the fading images of dreams. The lessons of time and the teachings of experience cannot be properly communicated through the confused and inaccurate memory of those who have only heard of, and have not personally seen and known, what they state as facts. These may not, perhaps, fail in the possession of an inward and organic consistency, and yet their details may be inexact and their information misleading. Uncertain and undated, as they mostly are, their traditional vagueness and frequently mythic character call for hesitation and reserve in accepting them, and require investigative research into their authenticity, accuracy, likelihood, and reality, before we exalt them to a place in history.

History—properly so called—is a connected and continuous narrative of facts and events, accompanied by or resting upon authentic details of circumstances, time, place, agent, and authority. It is the setting forth, in a properly verified form, of such statements of facts as have been duly inquired into, and found to be true in themselves and correctly related in order of time, cause, and effect, or other method of mental connection. "The essence of history is to be true." The registration of actual facts and real transactions in their successive stages and in due course from origin to end, all properly guaranteed as being vouched for by trustworthy evidence, is demanded of the historian. The historian may accept and even state facts in the most naked simplicity of style, and let the truth be seen through his words in the most transparent manner; but he is expected to have scrutinized, with the care of an expert, all that has been communicated, and to have investigated with the acumen and impartiality of a judge all that he states as truth.

History is the mirror of the past, and all the shifting scenes and all the passing procession of events exhibited in it must be undistorted and shown by the single light of an unbiassed mind. Its incidents must have the bloom and beauty of reality, not the heightened colour of art or the hectic of disease. Historic truth should illuminate, not decorate, events. Pictorialism is quite in place, if the art is reproductive and the original is used; but it is out of its proper sphere when it gives us artificial representations and imaginative scenes instead of views in precise conformity with reality. "History is philosophy teaching by example," when the example is well-chosen and real, and the incidents are exactly stated. It is not the historian's province to mould the past into shapes of exquisite form and dainty colour, or to sculpture the rough blocks of fact into finely chiselled statuary breathing the fresh life of the newly infused spirit of the Prometheus who fashions it to his own mind. He is rather the restoring architect who builds up the ruined walls, and raises again the temple, the palace, and the home in which the past occurred, and quickens the dry bones of the valley with the spirit of their former being.

All men are influenced by the curiosity which history gratifies. They desire to know what had transpired in the past, what deeds their forefathers had achieved, what they had laboured for and won. Historians know that there is a principle in the mind eagerly active in seeking a knowledge of the ways and manners, aims and interests, successes and failures of their predecessors. This is an interest to which they are aware they can appeal; and they record their testimony concerning the things among which they have lived, in the sure and certain hope that men will recognize their services with gratitude, and perhaps employ the light of their lamps to guide them on their further pathway. The close connection which is felt, in ourselves, to subsist between the circumstances of our lives and the course of conduct we pursue; and the clearness with which we can each trace the influence of what others have done affecting our own characters and conduct, cannot fail to aid us in perceiving how the circumstances of men and the events of the past have necessitated the events of succeeding times, and so lead to an understanding of the worth of history as an inherited experience. We readily understand that if certain accepted principles and truths operate upon men as motives to action, and they continue to be incited or governed by the same influences, similar results are likely to follow; and that proper causes being properly set in motion bring to pass their intended effects.

As the number of instances becomes greater, and the certainty of their likeness and recurrence increases, we should have a growing proof of the benefit of historic knowledge for guidance in judgment, assistance in action, and help in doubt. We learn, hence, to transfer the experience of the ages of old to our own times, and to deduce from their records principles to regulate our own actions. The Roman sage was right who said, "Not to know what happened before we were born, is to remain always children." History is the tale of "what happened before we were born"—a long, indeed, but not an unimportant story now. The incarnated wisdom of ages, the practical experiments in living made by myriads, are all in it brought forward and registered for our information. The migrations and commotions of nations, the growth and developments of sciences and arts, and the purposes and progress of civilization, are all exhibited therein to us that they may be contributors to our better being.

History is the drama of social life. It has its opening, its varying scenes and characters, its incidents, its moments of crisis, its dependence of event on character and circumstance, and of frame of mind impressed by what surrounds it. It cannot be, like a drama, divided into acts and scenes, and portioned off for performance among actors and supernumeraries, with opportunities of preparation and rehearsal, promptings, and giving of cues. It has undoubtedly its Divine Director, and in this sense Guizot is right when he calls it "The Drama of God," who is its Author, but the *rôles* of all the men and women who play their parts upon the stage of the world require to be extemporized by them in word and act and enterprise. They can only be well prepared for approving themselves proper contributors to the carrying on of the plan by knowing thoroughly all that has gone before, being in genuine sympathy with the whole situation and its requirements, and by having some well-formed conception of what ought rightly to come next in the progressive programme of possibility. If we desire to take such a position among the actors in the world's divine poem of reality, we would require to follow Bacon's advice, "that the principal books of every century be regularly consulted downwards" through all extant histories, or to have provided for us, by competent persons, some exact and authentic outline report of the preceding state of things up to the point at which our own part in the action comes on. This last is what is usually done, and accordingly historians have spent laborious years in studying and arranging the records of the past, and have drawn up for our behoof brief handbooks of the phenomena of the ages, by which we may be apprized of the main incidents and events in succession to which we, along with others, have to produce a sequel consistent with what has gone before, keeping up the whole spirit, interest, and energy of the business unflaggingly, yet always ready to pass off in our turn, and give place to those who are to enter on the scene

and play their part in the plot. Ignorance of the origin and progress of affairs, either in our own case or in the case of those for whom we are responsible, must have a prejudicial effect on the general result, and therefore to secure an adequate acquaintance with the past should be both a duty and a delight.

"Looking before and after" has been said by Shakspeare to be characteristic of man. History is the field-glass through which we survey the past and reconnoitre the future. Along the extensive backward view we trace the pathway through which "the world's gray fathers" have progressed towards the point at which we are at present stationed, and when we turn it forward we see some little of the road on which we must follow and our successors are likely to tread. The trials, struggles, troubles, endeavours, failures, and successes which the story of bygone years brings before us, indicate pretty truly that our place in the pilgrimage, or mayhap the warfare of life, will not be all (and always) plain, smooth, and pleasant; and that cross-roads may lead to difficulty, or cross-currents of fate and fortune may assail us. Thomas Fuller, in his own quaint, quiet fashion, says truly enough, in one point of view, that "History maketh a young man to be old without either wrinkles or gray hairs, privileging him with the experience of age without either the infirmities or the inconveniences thereof." These rare gifts of ripe experience and wise judgment, without enduring the woes of the former or undergoing the painful processes by which the latter is acquired, which the genial gossip to whose research we owe "The Worthies of England" regards as the greatest gains of the student of history, are really less advantageous than the guidance history bestows on those who examine the causes of human progress and the formation of social character. It can be made "operative to the endowment and benefit of human life" by its exposition of the reasons for the turns and changes which take place among nations; and thus shows us what we should encourage and what avoid. Bacon rightly says, "Whosoever is not supported by examples and the remembrance of things, must always be exposed to contingencies and precipitancy." Hap-hazard and rashness are the characteristics of youth, and history, by opening to us the note-book of time, with its inductions of incidents and narratives of events, supplies examples against aimless peradventures and random risks, and remembrances which indicate the inward springs or the original causes out of which memorable actions issue. We know how often "that unconscious science," of the possession of which all men feel themselves so fully conscious—common-sense—is supposed to be quite sufficient to deal with circumstances as they arise. Real common-sense, however, is not an instinctive instantaneous suggestiveness, but man's natural sagacity and prudence exercised intelligently on what is unknown in accordance with what experience had shown to be advisable in what was known. It implies therefore a historic element of experience by which identities are traced and differences are observed, and has instances and remembrances as the basis of its decisions. History is the record of the actions of men in multitudes, quickened by free-will or compelled by enforcement to act concurrently for the production of a designed effect. This holds true alike in social, political, military, industrial, scientific, or religious history. Action is the outcome of thought. Men's minds are bent by thought on certain achievements, and their efforts result in effects. Everywhere in history thought passing into and governing action presents itself to view. Seeing how the underlying thought of the past has wrought out its purposes, and the plans of others have manifested themselves in successes or failures, men regard it as advisable that the phenomena of life should be registered for reference and made available for guidance. In the perplexities of the present and the anxieties involved in making provision for the future, history preserves for us the inductive experiments made in olden times in diverse circumstances by different men or bodies of men, for the accomplishment of like or somewhat similar aims, and enables us to classify and compare these with what is proposed now and may be projected as desirable. If we can trace the chain of causation (as it is called), linking together certain means to general success, or can see by certain intermediate influences this causative connection interfered with, and failure being the result, then history supplies guidance for the future; and experience—learned without the cost of personal endurance—and judgment exercised on what has happened before, prepare us for determining what is best in regard to what is happening now and is demanding decision.

History is to society what memory is to the thinker. It supplies the records of experience out of which guidance and inspiration are to be evolved. To make it or regard it as a mere chronology, a collection of dates and events, reigns of sovereigns, wranglings of politicians, and wars of states, is to hold a low view of it and to lessen its worth. It is indeed the note-book of time, but it is also a suggester of purpose and progress. It reports the sayings of prophets and sages, the doings of legislators and patriots, the accession and demise of potentates; but it should also exhibit the principles which provide for the prosperity and progress of the people. This is simply the application of the law of causation to the explanation of the phases of politics and the condition of societary states. History may be written for the entertainment of the mind. In fact, this is probably the main reason of its being first written. We delight in knowing what is going on among men, and we take a curious interest in learning all that we can of our forefathers and their doings. Tradition, with its many stories of the past, is the history of the tent, the camp, the fireside, and the village green.

History is the recital of the actual work done by man in the world as sage, warrior, statesman, worker, thinker, singer, or sufferer. It narrates the origin of social institutions and political movements; describes the subtle influences of the human heart, out of which changes in states, empires, industries, and life proceed; and shows how all action and progress were once thought, feeling, and purpose. We like to hear how men have lived, wrought, and died. A faithful record of those events in which humanity has been concerned gives us pure pleasure, and the entertainment we derive from it is so great that we invent fictions, which are valued just because they resemble history in their eventfulness and human interest. It cannot be doubted that a historian's pages ought to be entertaining in the truest sense of the term—engrossing in its interest, pleasing in its style, and capable of keeping alive our whole faculties by its presentations of the past.

History has other functions, however, than that of being an immediate ministrant to pleasure. We require from it information. Our life is not cut off from the general stream of social existence. Our circumstances are often similar to those of our predecessors, and we wish to know what they did and what results followed. We frequently feel that we are involved by the acts of our forefathers, and we are interested in knowing why we are so, and what are the conditions on which this state of things depends. We perceive that events having a certain similarity to others which have occurred before are tending to an end not quite clearly foreseen, and we would fain inquire at history—what results followed like collocations of circumstances in the past? This is "history teaching by example;" this is making by induction from the past "a philosophy of history," and acquiring from reality, not from imagination, guidance for our lives. "Example is better than precept." History is a storehouse of examples, and hence, as Polybius says, "History is the best school in which men can learn how to conduct themselves in every condition in life." It is this power of informing the mind which makes history so fascinating. It awakens attention, quickens and widens experience, improves and strengthens the intellect, and blesses and benefits the heart. It creates a sense of sympathy, excites the glow of admiration, stimulates to imitation of what is right and noble, and produces abhorrence of the mean and base. It is a moving panorama of the doings and discoveries, the desires and wants, the opinions and the objects, the principles and the practices of men, in which we see how all have wrought together to bring about the state of the nations in our day, and have suggested to us how we too, with our ways and workings, shall be observed and brought before the opinion of posterity for being what we are, doing what we do. The utility of history as a series of carefully recorded experiments in the art of living, and of their

results in varying circumstances, is as undoubted as it is valuable.

There is no possible gain to man's spirit which can outvalue truth. Truth is the absolute selfsameness of expression and of impression, of the real and the recorded. Where truth in phase and phrase exactly coincide, work and words precisely represent each other, and like

> "The swan on lone St. Mary's Lake,
> Floats double—swan and shadow."

History, as the mirror of social life, should be equally clear and pellucid. Act, fact, and compact should each be seen in precisely coincident statement, free from disturbing passion, darkening prejudice, or distracting rivalry of sect or party. Prototype and antitype ought to be similar, as seal and die, and be as uniformly and truly reproduced as the sun's face is flashed into and reflected from the dewdrop in a daisy's cup. To see everything in the light of truth, is the highest and best of all possible seeing. It is true singleness of sight. That is the light which illumines; not the blaze which irradiates, yet darkens. History, which reproduces reality in *facsimile*, is a blessing and a benefit. It can be trusted in, acted upon, and made the basis of proposals for the future.

The qualities of history ought, then, to be trustworthiness and accuracy, comprehensiveness and lucidity, unity of conception and plan, and thoroughness of interest. It ought to charm by its incidents, instruct by its precision, delight by its reproductive liveliness, and attract by its fine fitness of phrase. It must be real—a record of true events; current—passing on from event to result in time and causation; definite as to time, distinct as to place, precise as to person, accurate as to action, correct in tracing consequences, clear and consistent in narrative, and wise in comment. It may be poetical in vividness of portraiture, philosophical in method and exposition, and fascinating in form and style; but it must be particular and true in representative reproduction. No pleasure aimed at, no utility striven for, no effectiveness of statement or plea can atone for or be accepted as an excuse for the neglect of truth in history.

The historian should be clear of eye. His vision must be unimpaired by partiality. His integrity ought to be unimpeachable, and his moral judgment as flawless as sunbeams. His power of representation should be photographic in exactness, and marked by artistic selectness, suggestiveness, and simplicity. Besides this, he must be able to appreciate light, shade, and colour, and know the precise faintness or intensity of every hue of moral greatness or turpitude. Careful sifting of authorities and unbiassed examination of facts must be combined with natural keenness of penetration and incorruptibility of historical judgment. Arrangement of material, form of plan, style of narration, selection of incident, order of fact, and reflection and relation of one event to another, all require peculiar powers of perception, classification, and organization. They ought not to be "dry bones," but living creations, which appear in history. On the great stage of the world mimes and puppets must not occupy the places of men. It is a life-picture of the past we require. Not a painted dream, but a performed drama.

The duties of a historian are important, his responsibilities great, his qualifications rare, and his task severe; but his fame and usefulness are abiding and choice. Among the mighty of intellect for consummate sovereignty over the soul, who have ever excelled the hierarchy of the historians? Even epic poets only imitate—dramatists merely emulate the realities they record. The novelists and romancers simulate what they represent. The historian's is the diamond whose facets glow with inner divine light; the poets only collect and recrystallize diamond dust; and the fictionists cut or mould glass into likenesses of the pure and natural transparencies which the historian sets in brilliants and arranges in shapeliness. Historians are, in truth, the explorers whose eyes see what we cannot perceive, and who bring from the far-off past the material and the means of entertainment, information, and delight. It is the perpetual privilege and the everlasting task of man to learn from the past the lessons which Providence has arranged that each generation shall acquire from the past, and apply to the purposes of present life and future progress.

History may be used as a recreative entertainment for its interest, as a moral training to the judgment and the heart, or as a source of information and material for thought. It is above all other topics fitted for study. Pope said "The proper study of mankind is man," and men have generally accepted the saying as a proverb. It has special claims on attention for its subject, and the attractiveness of its matter has obtained universal acknowledgment. The facts of history should be clearly discerned, the course of events carefully traced, the causes of change thoughtfully considered, and the reasons for incidents critically examined; while the characters of all the main actors in society ought to be subjected to special scrutiny as to their motives, tendencies, and powers. The mind should be kept open to impressions and alive to influences arising from what we read, and the current of the history should be traced not only from its source and along its course, but in the side-issues and episodes which may be seen on the margin of the stream. We ought to endeavour to trace the progress of passion and purpose of plan and cause, of war and diplomacy, of peace and industry, of commerce and art, of social movements and political proposals, of statesmanly power and popular freedom, and of science, law, and religion among men. So studied, history will be an illustrated lesson-book on life, progress, and providence; on man, societies, and civilization; on duty, responsibility, and faith.

In the history to be placed before the reader in the following chapters we propose to take for our starting-point, not the earliest pages of time, but the most crowded with incident and interest. We shall take that great central sovereignty which held sway over the mightiest sweep of territory under one dominion in the era of Christianity, and as we trace the course of its conquests we shall indicate the state and condition of all the nations with which it came into contact, and shall thereafter carry on its history till Rome resigns to other sovereignties the sceptre of power; and then describe concisely, yet we hope fully, the rise and progress of modern states from their origin till the present time.

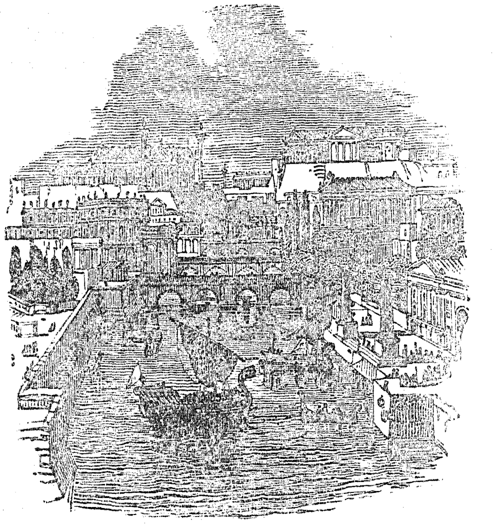
THE HISTORY OF ROME.—CHAPTER I.

THE MYTHOLOGICAL AND LEGENDARY ERAS.

EUROPEAN civilization has its earliest scene on the coasts of the Mediterranean. At the dawn of history we can descry a thin belt of comparative civilization encircling the coast of this great inland basin. This belt deepens and extends, more especially in a northerly direction, into the continent of Europe. That portion of coast-line to which we shall here confine our attention is marked out by very definite natural boundaries. Casting the eye over the map of Europe, at the widest part of the Mediterranean Sea a boot-formed projection of land will be seen shooting out from the continent. This is Italy. At the northern border of this long narrow strip of land the Alps stretch in a semicircle from sea to sea, and form a natural line of demarcation between it and the north of Europe. From the western elevations of the Alps, the chain of the Apennines sweeps in a curve nearly along the centre of Italy, till it approaches the southern extremity. There it divides into two branches, each terminating on the sea-coast; the one at what may be termed the heel of the boot, the other at its toe, upon the strait which separates Italy from Sicily. Italy stretches from 38° to 46° north latitude; it therefore lies entirely within the warmer section of the temperate zone. The height of the central mountain range, and the numerous narrow valleys intersecting it, conspire to modify its climate. The weather of Italy is more variable than, from its position on the globe, we should have been led to anticipate. There is in consequence, too, a great variety in the comparative fertility of its valley-lands.

We are now about to trace the fortunes of a state which, occupying at first a scarcely perceptible space on the surface of this district, came in course of time to rule over the whole of this Italy, and then to identify Italy with itself. About

the middle of the Tuscan Apennines are the sources of a stream, which, flowing in a south-west direction, and forming the central drain of a wide valley, reaches the sea by two branches. This is the Tiber. As it approaches within some 16 or 20 miles of the sea, it forms a curve. Nearly at this curve the Tiber receives the waters of the Anio from the south-east. Not far below the junction of these streams—



Ancient Rome.

the names of which are "familiar as household words"—on the left bank of the Tiber, stands the city of Rome. This was at one time the capital of the whole known civilized world.

It will be advantageous to distinguish the historical plain which we require to traverse into five divisions, marked by characteristic features which the mind easily recognizes. These five divisions are respectively :—

I. The mythological era of Roman history.

II. Infant Rome: the development of the constitution of Rome within the city walls, down to the election of the first plebeian consul and the burning of the city by the Gauls—events which happened respectively in the years 363 and 387 of the city.

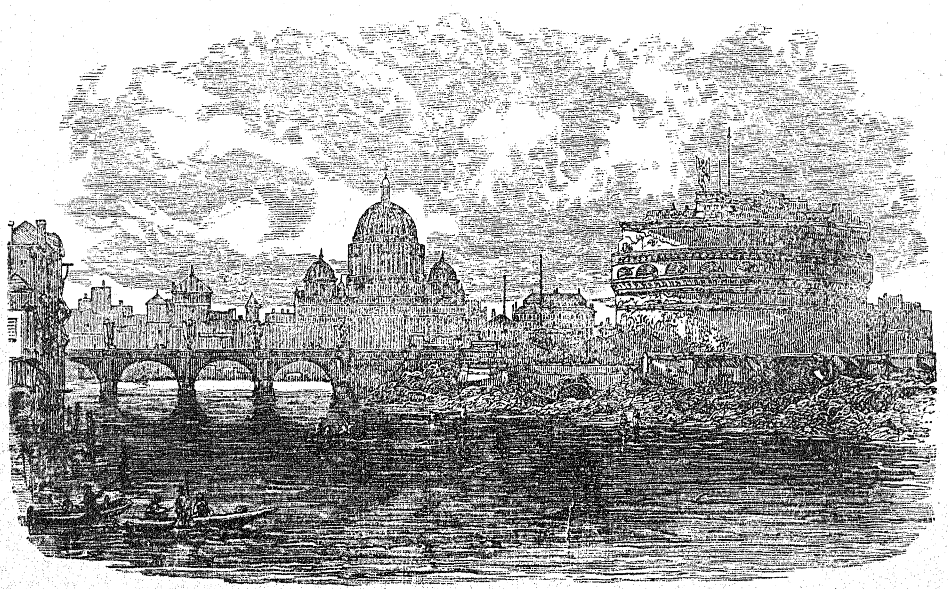
III. The period in which Rome was bringing the whole of Italy under her sway. This terminates about the commencement of the first Punic War, about the year of the city 490.

IV. The series of transactions, foreign and domestic, which terminated, shortly after the close of the Jugurthine War, in the amalgamation of Italy and Rome, and with the admission of all Italians to the right of citizenship, in the year of the city 665.

V. The period of renewed struggle of factions, under the developed constitution, which was terminated by the successes of Cæsar, in the year 703 of the city.

It is not to be understood that these distinctions into periods exist in reality. The current of history is uninterrupted. The events of one moment of time are interlaced by a thousand minute fibres with each other. These periods are merely marked out as aids to memory. This remark is made to prevent misconception.

I. The first period embraces the mythological history of Rome. Legendary tradition is distinct from history; still the legends of a nation form no unimportant part of its biography. They are illustrative of its character. As the heart feels the imagination conceives. The heroes and demigods of a people are the embodiment of what the men of that nation most admire—of the qualities on the possession of which they most pride themselves. Nay, the constant habit of having heroes and their exploits held up to admiration, tends to form the character of a people. Legendary lore is first stamped with the moral character most esteemed among a race; but when it has once attained a definite form, it reacts upon them with even more force than they acted upon



Modern Rome.

it. The legends of a nation are that nation's passions reflected and enlarged—like the spectre of the Brocken—on the clouds of the imagination; and men are pleased with this colossal image of themselves. It is because national mythology is a living and enduring reality in the national imagination—its idolatrous worship—the strengthener, when not the origin, of its peculiarities, that we should know it, in order aright to know the nation itself.

It is not easy to learn the details of Roman myths and legendary fables. The Roman authors are all more or less imbued with Grecian as well as with Roman poetry. What they give us is a compound of these two elements. That there was an indigenous system of superstition in the valleys of the Anio and Tiber is clear enough; but it is hard to say, of what has been transmitted to us by Roman authors, how much flows from this source and how much has been borrowed by them from the Greeks.

Rome is seated on seven hills. Some miles below the junction of the Anio and Tiber, there was a low marshy plain, on the left or southern bank of the united waters.

round which the stream made a bold sweep. Landward, the rising grounds toward Mount Algidus inclosed this marsh. In the centre stood an isolated, steep, and craggy eminence, afterwards designated the Capitoline Rock or Hill; and between this and Mount Aventine—the most westerly of the prolongations of the uplands mentioned—stands another isolated mount, designated in after times the Palatine. From these five tongues of elevated land the country continued to ascend to the south by a scarcely perceptible rise, till it reached the base of that extinct crater which forms the bed of the Alban Lake, behind which, rather to the eastward, towers Mount Algidus. Eastward, there was a considerable tract of level land, lying on both sides of the Anio, and extending to the left bank of the Tiber. At the eastern extremity of this plain ascend the bold crags, within which Tivoli is embosomed. North of the Tiber was a rocky land abounding with small lakes, the beds of extinct volcanoes. This land was channelled and fretted, like the wrinkles on an old man's face, by innumerable streams. Toward the sea-coast, that is westward of the city, the elevation of the soil sunk rapidly. On a line with the city, and further inland, the rocks are all of volcanic origin—chiefly a kind of tufa; on the other side sandy barren tracts alternate with salt marshes. Rank and deleterious vegetation clothes the one; the other is covered with forests of evergreen, oak, and a kind of cork-tree. The same deep forest growth hid the base and ascent of Mount Algidus.

Amid this rude but not sterile country, several states had sprung up before the foundations of Rome were laid. The towns of Etruria pressed upon it from the north; the Ascans, Volscians, Samnites, Hernici, &c., from the east and south-east. The kindred Latins occupied a narrower territory to the south-west. The Romans borrowed some elements of their mythology from these surrounding states. This circumstance seems to have given a fragmentary and mechanical character to the Roman mythology. The early names of the indigenous Roman gods have perished; but their characteristics have survived, and they have a strong smack of their natal soil. One of the most prominent was Fever—a natural goddess in a land of marshes and miasma. Another was Terror—a strange panic-striking being, which now stupefied the Roman and again the enemies' ranks. Another was the power which breathed courage, enduring resistance, into the breasts of men; and another was the god of good counsel. To all these powers we find altars erected in early Rome. When we come to the period of the antique legends of heroes and the strange traditions of the early priesthood, we recognize the vigour and the rudeness of the age in which they originated. Rapacity, craft, and courage are the most admired characteristics of the early heroes. Continence is a virtue, because it is conducive to strength and martial vigour. At the altar alone was there safety for man, beyond what his own skill and valour could insure him; and even there protection was only precarious. The first moral admixture in this lawlessness of will and imagination, is the injunction of continence as a strengthener of the warrior's arm. The next was the practice of justice and kindness to fellow-citizens. Hatred and contempt of the foreigner were allowed, and even encouraged. These narrow virtues—like those of all rude nations—were the result of calculating selfishness. But the habits of self-restraint which they prompted, in course of time, lent greater grace and nobility to the character. To save a Roman citizen in battle was to earn the proudest of the wreaths bestowed on victors. From the earliest periods of the recorded history of Rome we find women occupying a happier position than in any other state of antiquity.

These were the elements of the popular mythology and traditions of Rome. The secret knowledge of the pontiffs and augurs was a very different thing. Superstition is of indigenous growth, and gets fashioned into a kind of consistency by lapse of time, not by deliberate forethought. The elementary powers of nature wielded, according to it, sovereign sway. The advancement of the nation in a rude morality communicated in time something of a moral character to their deities. The ferocity of savage enthusiasm became regulated rather than softened. Down to the close of the Roman republic, the *virtus* which the Romans admired was more akin to valour than to what we now call virtue. Reaching back into the past in order to confer at least a bygone eternity upon the deities of their imagination, the old traditions of volcanic agency were blended with other elements of awe; and hence the pit of Acheron, the fire-breathing Cacus, and other inflammable apparitions. Superstition filled the popular imagination of Rome, and domineered over it for centuries. The outgrowth, in the first instance, of Roman character, it became mainly instrumental in keeping the Romans what it found them. To understand the Roman aright we must remember that this belief was ever present and powerful in him; that whatever physical objects might greet his eye, these were ever near him, "Lords of the visionary eye, whose lid falls not and cannot fall." Dreams we may call them, but they regulated the actions of a powerful people for a thousand years; and they have outlived their dreamers!

GEOGRAPHY.—CHAPTER I.

GEOGRAPHY DESCRIBED AND DEFINED—THE RELATIONS BETWEEN HISTORY AND GEOGRAPHY.

Of all the systems of that magnificent spectacle of order, harmony, and beauty which we call the universe, that within which the journeyings to and fro of our own *home-planet* is confined most nearly and most immediately concerns us. Even that circle of swift-whirling orbs, small as it is compared with the immensity of worlds which wheel through space and stretch beyond the limits of human conception—unless in some highly favoured mortal in some glorious moment of special inspiration and entrancement—is found to be, for most men, too heavy in its demands upon the intellect. Hence we are glad to separate, as it were, in our thoughts, the earth on which we dwell from its co-travellers in space, and fix our attention upon that as a sufficing object of study. *It* contains within its circle the greater portion of that which stirs our hopes, inspires our joys, or awakes our fears. Our sympathies—personal, domestic, social, and national—are interwoven with it. Our inborn curiosity, touched into activity by its charms and gratified by its revelations, induces us to inquire with earnestness into the phenomena in the midst of which we are set. The scenery of earth, ocean, and sky are felt to be not merely the petty adjuncts of "our little life," but mysterious realities demanding examination and study, because our existence is, with ineffable consummateness, inwrought together with them in singular intimacy. All the perplexing complexities of our surroundings we cannot comprehend; yet we anxiously seek some knowledge of the mesh of phenomena enwrapping us, of that indefinite and infinite perpetuity of occurrences and recurrences of which we are permitted for a brief space to be the spectators, and among whose marvellous evolutions and revolutions our life is to be spent and our life's work done. This study of the earth as the habitation of man, in its place among the hosts of the sky, as an object of curiosity and interest, and as a revelation and suggestion of marvellous truths and fascinating thoughts, receives the name of geography.

Geography is, in a great measure, a derivative science. Many of its facts are adopted from other sciences, and are accepted as postulates by it. From astronomy it receives its knowledge of the position of the globe in reference to other celestial bodies—its form, size, motions; the theory of eclipses, the explanation of the procession of the seasons, &c. From geometry it acquires the power of representing, by artificial means, the forms of its various parts, the mode of ascertaining the longitude and latitude of places, and the various methods of admeasurement which it requires to employ. Geology supplies a knowledge of the form and distribution of the solid portions of its surface. Hydrography imparts similar information regarding its fluent constituents; and meteorology provides such lessons about its aeriform vesture and the changes which take place therein as may be relied on. Chemistry details the nature, properties, and modifications (past or possible) of the elements which compose it. Dynamics and statics describe the forces and influences which

operate in or rule over its motions, and mechanics details the variations produced or producible in its materials by the action and interaction of forces or agencies for applying and directing force. Ethnography, zoology, and botany unite to tell us the races of animals and the species of vegetables which had their habitat upon and now occupy the earth. Electricity and magnetism seem to pervade the universe, and produce or affect some of the grandest and most intricate phenomena of nature; and the sciences which deal with them explain to the geographer the secret of thunder and lightning, the aurora borealis, the variations in the needle of the mariner's compass, &c. History records the successive mutations of race, dynasty, government, industry, incident, condition, &c., of man during the past; political economy makes known the laws which govern these mutations; and statistics note for us the results which have flowed from the operation of any or all of the causes which are brought into light by historical or economic research.

It has always been found difficult to fix within definite limits the matter of geographical science. It has even been thought right to keep the range of it as wide and vague as may be, so long as the knowledge included in its sphere and scope was useful. So vast indeed is the material included in any adequate science of the earth—as the theatre in which all the powers and laws of nature are displayed through an infinite variety of operations and changes — that it has been felt that a new name might very appropriately be given to it, and it has been proposed to call it physiography (Gr. *phusis*, nature, and *graphe*, a writing), the science of nature. Such a science truly would—like Aaron's rod—swallow up all competitors, and be itself at once a science of the universe and a universal science. Even were such a science formed, and all experiences with all the truths they yield were comprised within the sweep of its dominion, we should still require for convenience' sake a separate sectional science which should bring together for us, in some comprehensible unity, a knowledge of so much of the truths it had gathered together as would explain the nature, extent, condition, and place of the earth as the temporal abode of man. These would probably arrange themselves so as to supply accurate and systematic information concerning the earth's form, position, surface, population, and products, and the condition and changes of the surface of the earth, since it was, and because it has been, and is, the habitation of man. The former would constitute physical, the latter political geography. While, therefore, not desirous to contract the sphere or lessen the scope of science, we shall collect and set forth, as fully and faithfully as we can, the materials furnished by the several sciences which in their aggregate provide what the Germans call an *erdkunde*, a knowledge of the earth.

"Geography" literally means a "written description of the earth." It is derived from the Greek words *ge*, the earth, *graphe*, a writing. Geography might therefore comprehend a description of everything both upon the earth and under its surface: land and water—mountains, plains, seas, and oceans—plants, trees, and shrubs—every species of land and water animals—and man in his moral, religious, social, and political condition. Geography, in this sense, might also include (1) a description of the earth as one of the planets of the solar system, revolving round its own axis every twenty-four hours, producing day and night; and round the sun in a year, producing the alternations of the seasons; (2) a description of the composition of the different rocks and soils on the surface of the earth, of the various strata which are said to constitute its crust, of the animal and vegetable remains found in these strata, with disquisitions on their history, formation, &c. Geography would thus absorb into itself the sciences of botany, zoology, astronomy, geology, and mineralogy. Although no geographical treatise would be complete without, to some extent, calling in the aid of these sciences, the term "geography" is generally used in a much more restricted sense, namely, to signify that science which ascertains or determines all the external facts relative to the various countries on the globe which render them fit or unfit for the abode, the comfort, the happiness, and the civilization of man.

Geography supplies a description of the different countries, kingdoms, states, cities, &c., on the earth's surface, and of everything therein relating to the condition of the human race. It ascertains in every country the proportions and situations of land and water, internal seas, lakes, and rivers—the size, elevation, and position of the different mountains—the extent and course of the rivers—the nature and position of swamps and bogs—the extent of the plains, &c.; it informs us of the nature of the soil and vegetation, whether they are adapted for agricultural purposes, for grazing, and for the raising of food and clothing for man; the climate also must be taken into account as bearing in a marked degree upon the health, subsistence, and social life of the inhabitants. As no country ever rose to a prominent position in the scale of civilization, unless possessed of ample capabilities for trade and commerce, everything—whether mineral wealth, agricultural productions, animal or vegetable life—which can, either directly or indirectly, originate and extend the commercial prosperity of a nation may fairly be included in a treatise on geography.

A general knowledge of geography is now considered so indispensably necessary for every one, whatever his rank or station in life, that the rudiments of it are taught among the elementary branches of education. No one can open a book of history, of voyages, or of travels, or even a common newspaper, without meeting puzzles and difficulties in every page, and without losing a great portion of the instruction and information they contain, unless he possesses an accurate knowledge of geography.

It is evident that the conditions of nations must greatly depend on the position they occupy. The Jews, for instance, were concentrated and confederated not only by their specially theocratical constitution and worship, but also by their location on a strip of land about the size of Wales on the very frontier of the East—insulated as they were, on the one hand, by the enormous trench of the valley of the Jordan from the mainland of Asia, and hemmed in by the Mediterranean, to them "the Great Sea," from progress westwards on the other. Greece again, from its peninsular position, its large extent of coast, its exceptional facilities for approach and egress, as well as its island-studded Archipelago, was admirably fitted for a nation of adventurous and enterprising colonists, a warlike and restless people, and a race of seekers after wisdom. Our own insular situation, too, has had a great effect on our national character and our place among the seafaring populations of the earth. Even things of less importance, as some might think, exercise a remarkable influence over states and people. The fertility or barrenness of the soil, the nature and variety of its products, the possession or want of minerals and metals, and whether these are precious or useful, modify the industries, the mode of life, and the character of those who settle in and dwell upon a country. We all know how the habits of the people on a rich alluvial delta, fruitful in corn and rice, differ from those who live on far-stretching, undulating prairie-ground, producing only food fit for cattle, which again furnish food for their nomad herdsmen. Forest land suggests huntsmen and timber industries; mountains, freefooted, imaginative, thoughtful occupants. The lands of the olive and the vine are those of poetry and music. Heat quickens passion and relaxes effort till self-indulgence becomes all-engrossing; while cold chills the emotions into torpidity, and slackens all the energies of the human machinery, till indolent inactivity becomes the special pleasure of existence. In this, and in many other ways, a knowledge of physical geography assists us in understanding the history of the past and realizing the condition of the present.

The geography of any particular district is a description of its physical peculiarities, including an account of its superficies, as it is shared between land and water, hill and valley, lake, river, or sea. Details of its products, artificial, animal, vegetable, or mineral, are given. All these things, as a little reflection will suffice to convince us, constitute important parts of a nation's story. The temperature of a country's climate influences strongly, not only the habits of men, but also their innate character and disposition. In cold climates the necessity of warm clothing and the difficulty of procuring

adequate food, it is easily seen, will produce provident and active habits among the inhabitants. In warmer climes we find a greater susceptibility among the native races, a quickness of apprehension, and a greater delicacy of taste than we find among the dwellers in colder regions. In natives of the north, on the other hand, we find more steadiness of purpose, superior powers of previous calculation and arrangement, and a more solid and firmer texture in their mental capacity. The necessity of our nature, under these circumstances, will lead men in different localities into widely different spheres of activity, calculated to develop in varying and unequal degrees the dispositions and faculties of their minds.

Again, the changes which, through the succession of periods of time, take place in the geographical condition of a country, will exert an influence in modifying or altering the manners and dispositions of its inhabitants. It is impossible minutely to analyze these changes which may take place in the features of a country. It may be stripped of its trees, and thus its climate will be altered. The sea may have receded from or encroached upon its shores; mineral treasures may have been discovered, or the art of making them available may have been lost. Many other variations may from time to time occur in the geography of a country, calculated to produce changes in the condition and character of the inhabitants; and the knowledge of these is indispensable to the proper understanding of its history.

The natural divisions of the earth, though they influence the position and relations of nations, do not, however, altogether control them, and we find ourselves induced to consider the artificial divisions into which, at different periods, portions of the surface of the earth have been partitioned and settled. An acquaintance with the distribution of races, nations, and languages, helps us to comprehend how the migrations, the unions, and the separations of communities have arisen; and how, too, intended changes in the relations of peoples have been checked and frustrated by physical causes, and commercial, economical, or political reasons founded on them. A clear apprehension of the localities in which great events have happened aids the mind to realize them, and a knowledge of the comparative strength of nations —commercially, politically, and numerically—enables us to understand how transactions took the turn they did, and the changes which surprised the nations themselves, occurred.

The order of nature, as exhibited by geography, affords many proofs of the supreme wisdom and goodness of the Mighty Maker, Controller, and Providence of the universe. We cannot avoid perceiving that God has fitted and arranged the surface of the earth, and imparted their special characters to its productions, that it might be the residence of men; and that men—by observing, following, and realizing the purposes of the Most High, even when the knowledge of them is gained only by groping towards the light—are brought, often by ways that they know not, to undertake the emigrations and immigrations which have had so large a place in the history of mankind. Here again we find the relations between history and geography insensibly blending their lessons and their interest. How singularly, for instance, might the history of England have been changed had Henry VII. been less dilatory in accepting the offer of Columbus to take service under him as an explorer of the western seas, and so have won for England the glory and benefit of being the first to penetrate and possess the mighty continent of the New World.

CHAPTER II.

HISTORY, SOURCES, AND PROGRESS OF GEOGRAPHICAL KNOWLEDGE.

Sparse and scanty notices culled here and there from the pages of Hebrew, Greek, and Roman writers, are the only materials we have for constructing a geographical conception of the ancient world, or for knowing what idea of the surface of the earth was entertained by its earlier inhabitants. In the traditionary age, of which there are intimations among every race, man toiled on or wandered over the earth seeking the means of mere existence, and earned his bread by the sweat of his brow. Food was obtained by the tillage of the ground, or by the pursuit of wild creatures in the woods. A hewn-tree hut was raised for shelter, or a cave was cleared for a resting place. As men multiplied, they formed separate interests, and grew from families into tribes. Physical energy was in its prime, and soon gained predominance over other powers. The purposes for which it was used were conquest and luxury. A civilization, whose sign and proof was material grandeur, and whose basis was tyranny, spread abroad. Conflict with nature was a sad necessity of life, but sadder necessity arose—that of the conflict of man against man, tribe with tribe, and empire against empire, till war incorporated itself as the arbiter of fate. Escape from tyranny was sought, and the search for peace was made by migration. Thus, across river and over mountain, through forest and swamp, men were dispersed from inland centres to sea margins, and shaped out for themselves territorial claims and limits. These were defended by institutions, customs, and laws against the evils of actual or possible invasion, but these very defences at last became barriers against blessing and benefit. The bonds of race, nation, and state overpowered those of general brotherhood. Political geography was thus in the earlier ages influenced by physical geography. The records of the rise of nations, the migrations of races, and the establishment of states are all lessons fraught with interest for the geographer, for they convey the first glimpses and intimations we can get of man's achievement of a knowledge of the surface of the earth, its peoples, its products, and its phenomena.

It is difficult to separate, even in thought, ethnographical from geographical facts. In Gen. x. we have an early classified summary of the geographical knowledge of antiquity. Appearing at first sight as a mere ethnographical table, it is found upon examination to be arranged in geographical order. The information therein contained, supplemented by that given in Ezek. xxxvii., conveys concisely an outline of the knowledge of the world possessed by the Jews, surveyed from their own position on the maritime curve of lowlands which skirt the Mediterranean. Its sweep extends from Media and Elam on the east to Greece and Tarshish on the west, and from Gomer and the Caucasus on the north to Arabia and Nubia in the south. Their territory was a "promised land." It was surveyed, conquered, allocated by lot, and each inheritance in it was defined and inalienable. No country, as Milman says, "could be less dependent on foreign importations; it bore within itself everything that could be necessary for the subsistence and comfort of a simple, agricultural people." Surrounded, however, as the children of Israel were by nations which attracted and conducted the commerce of the ancient world, they were brought by their geographical position and their historical development into intimate relations with them and their pursuits. The story of the Jews could not be told without references to, and notices of, the neighbouring states. Egypt, Arabia, Phœnicia, Assyria, Babylon, Persia, Greece, Rome, &c., came into relation with the chosen people, and we receive from their records illustrations of their populations, customs, economy, products, and possessions. The Pentateuch, the historical books, the Psalms, and even the Prophets are sources of fuller information regarding the nations of remote antiquity than any other writings. Of course, the knowledge conveyed by the Bible on these topics varies in amount and value with the age of its books, and the geographical view of the earth it presents is considerably different in the patriarchal, monarchical, the exilian, and the Christian eras. Of no ancient territory can we frame from their own books so clear a conception as that of the Hebrews, and no other books afford so many side-lights regarding the geography of the nations of antiquity as the Bible.

Although every age has not had its geographical system—its classified compendium of geographical knowledge—every age has nevertheless its geographical theories. There is a propensity which leads men, in the absence of ascertained facts and correct inductions, to build up hypotheses, in many cases most baseless and extravagant. Such, for example, is the golden chain of Homer, by which the earth is suspended from heaven. Such is the Indian belief, that the world is supported on the horn of a cow, that the cow stands on an

elephant, the elephant on a tortoise, the tortoise on—what no one dare imagine. Theories like these, giving a form to men's notions of the world, existed long anterior to the introduction of systematic geography.

The Sources of Geographical Knowledge.—In reviewing the history of geographical knowledge, there are three great periods, each of which will be most fittingly and advantageously examined apart. The first extends from the earliest periods of which any written records have been handed down to us, till the bestowing of a systematic form upon geographical science by the school of Alexandria. The second proceeds from the introduction of this more systematic method of treating the science, till the age of Columbus. The third relates to the progress of geographical science down to the present day.

I. Concerning the first period, we are obliged to glean all our geographical knowledge from works devoted to other topics. The continuance of this period, as to time, varies in different nations: it is determined not by the date at which the more scientific form was given to the science at Alexandria, but by the date at which each nation in succession became acquainted with and adopted it. Of all the nations which were ultimately incorporated in the Roman Empire, and in which scientific progress was influenced by the school of Alexandria, there are only three whose records previous to this date we possess in their own language—the Roman, the Grecian, and the Jewish. A large proportion of Greek literature, containing by far its most original and valuable writings, belongs to this era.

Jewish.—The peculiar characteristic of the geographical details which may be gleaned from the Jewish writings is that of vivid and graphic reality—so long as the events of the narrative refer to the limited sphere of the heritage of that race. The boundaries of this sphere are not very distinctly defined. They extend from a parallel of latitude passing between Damascus and the termination of the chain of Mount Lebanon in the north to a line between the bottom of the Gulf of Akaba (the bifurcation of the Red Sea) and Cairo in the south; and from the Great Sea which washes the coast of Syria in the west, and the edge of the desert which lies between the fertile land to the east of Jordan and the Euphrates in the east. The relative position of the most important places within these limits is tolerably well ascertained; but their real distances from each other are rudely reckoned as so many days' journey. The general character of the country—as level or hilly, coast or inland, sand-waste or marsh, is faithfully indicated; but the extent, interruptions and intersections of mountain ranges are nowhere explicitly noted. Some of the most striking meteorological phenomena are correctly referred to; natural history, as far as it relates to the vegetable and animal kingdom, is insufficiently indicated, and this is still more the case with regard to the mineral kingdom. The incidental information furnished in the Scriptures is that of writers intimately acquainted with the localities of the central point and capital of their native land, Jerusalem. Every wider circle successively described is more and more vaguely known to them, and with regard to all beyond the limits of their own territory they are in utter ignorance. Their familiarity with the objects within the sphere of their acquaintance has had the effect of making their incidental notices of geographical phenomena rather expressions of the impressions of external nature upon a passionate temperament in a state of high excitement, than correct delineations of objects as they exist in themselves. They are therefore to be carefully and guardedly used for scientific purposes.

Greek.—The peculiar characteristics of the geographical details which may be gathered from Greek authors of this period, though they relate to a wider range of the earth's surface, yet exhibit frequently less accuracy, greater confusion, and hence occasion considerable difficulty in reconciling conflicting statements. The Jews were a very numerous tribe of Semitic race. Among them a family unity of thought and expression was kept up by their exclusive religious opinions and ritual. The Greeks were a natural family—their language, customs, and laws throughout that extent of the earth's surface over which they were scattered were much the same. But they were not like the Jews—one organized body. They had not one temple to which all eyes were incessantly turned. They had not a Levitical tribe dwelling among them, without a local habitation of their own, to remind them incessantly of their brotherhood and unity. Every city in Greece, almost, governed itself. Hence we may mention as a simple example of the confusion necessarily introduced into geographical details by this circumstance—that almost every city in Greece had its own peculiar standard of superficial measurement, and yet all these different standards had the same name. The difficulty of understanding or reconciling the statements regarding the distance between places occasioned by this circumstance is the least evil arising from it; often when one author only specifies such a distance, we are unable even to conjecture the length he attributes to the term he uses. The more precise and artificial methods of computing distances in Greece are often less informing than the rude estimates of the Jews. Another source of perplexity lies herein, that much of the information contained in Greek writings refers to lands foreign to their authors, and to periods which were ancient to them. Nearly the whole of what we find in the Jewish annals relates to their own country—there is no foreign admixture there; the narrative relates to scenes familiar to the scribe. The more locomotive Greek rambles over a wider surface; tells us of much with which he has become acquainted only by a single transient visit—much of which he knows only from hearsay. Not only is his knowledge on this account less exact and trustworthy, but he adds to the confusion we have already noticed as existing in his measures of distance, by borrowing the names of the measures of foreign nations to express the distances between places in foreign lands. To compensate for this greater confusion and vagueness, however, we find, towards the close of this era, among Grecian authors, a scientific spirit growing up, which brings them back to accuracy, and communicates greater fulness of knowledge in other matters. The military precision of the movements of Xenophon and Alexander, the care with which they were recorded by men of scientific attainments, give a definiteness to the details of the close of the Greek period superior to that of the Jewish. And the systematic inquiries of Aristotle into natural history and physical phenomena, furnish us with an amount of available information on these subjects of which no counterpart exists in the Hebrew writings.

Roman.—The geographical details to be gained from the earlier Roman authors have also a peculiar character, springing from the very marked national features of that people. With the Romans everything relating to matters of admeasurement was business-like and practical. In a class of writings repulsive enough in their form, but valuable as containing information nowhere else to be found, and hitherto too much neglected, known by the designation of *Agrimensores*, *i.e.* land-measurers, we find information respecting the manner in which the Romans were in the habit of measuring the lands allotted to their soldiers or citizens in conquered territories. We are thus certain that the Romans were, from the earliest periods of their history, nicely accurate in their measurement of the earth's surface for domestic purposes. Let us next turn our attention to their unrivalled system of tactics. Rome was to them but the central point from which all their excursions proceeded. Every seizure of territory by the Romans was made after a careful calculation of the food requisite to maintain it, the means of support for their forces, the amount of tribute which could be exacted by the imperial city, without altogether rendering the residents desperate, and the extent and facility or difficulty of transport on the roads leading to it. These calculations were made with the same precision and accuracy as in the measuring out of acres from the public lands to private citizens. Owing to this peculiarity of the Roman character, wherever that nation projected or effected conquest, the notices contained in Roman writers concerning that territory furnish us with accurate details of the distances between place and place—the first great requisite of accurate geographical information. The manner in which this outline is occasionally filled up is equally characteristic. It furnishes us with notices of the face of the country and its meteorological phenomena calcu-

lated to be useful to any one about to conduct military operations in it, with details of its products interesting to him who may have an army to feed in it, and such estimates of its wealth as are alluring to the mind.

In this period we are furnished only with materials. Our geographical knowledge must be constructed out of them. In executing this task it is necessary to keep steadily in mind the date of each work from which we extract information, seeing that in consequence of a nation alternately increasing by conquest from others, or being diminished by conquest from itself, the same name denotes at different periods very different extents of territory; that in some instances where both influences have come into play, the same name may be found applied at one period to a totally different portion of the earth's surface from that to which it is applied at another. It is, moreover, necessary to keep distinctly in view, that the immense majority of the writers and observers proceeded upon the assumption that the earth was one great extended plane, and that hence innumerable errors occur in their statements regarding the relative positions of places, their bearings to each other, the figures of lines of coast, and the directions of mountain ranges. In attempting to use their statements as facts, we must always remember (1) the point in time from which their observations commence, (2) the line along which they are carried on, and (3) the observer's preconceived notions of the figure of the earth's surface.

II. The second period of geographical science reaches from the systematizing of geography by the Alexandrian school to the age in which the researches of Columbus and his successors struck out new fields of investigation.

Alexandrian.—The Alexandrian school had rendered more service by its preservation of the works of original authors, and by its patient perseverance in the accumulation of facts in physical science, than by awakening or training powerful and original minds. The sedulous attention paid at Alexandria to the collection and preservation of the writings of the philosophers and poets of former times; the studies necessary for illustrating what time was rapidly rendering obscure in these writings, or for preparing new and more correct copies of them, produced a class of scholars to whom the epithet *grammarians* was applied. In this epithet in its original acceptation everything that was necessary to the elucidation of the classic writers was included, and among these not the least important was an acquaintance with the geography of many countries. Alexandria was frequented by visitors from all parts of the then known world; Alexandrians visited all parts of it. There were indefatigable thinkers in Alexandria, who availed themselves of both these sources of information to extend their stores of knowledge. While by this means one class of grammarians were accumulating the *data*, the facts of geography, the other was preparing to elevate it to the dignity of a science.

The systematic geographical works, which are the nucleus of our knowledge of the world, belong to its earlier writers. The most important are those of Pliny the Elder, Strabo, Mela, and Ptolemy. From them we obtain not only rich and minute details of the geographical facts of their own time, but of the geographical theory which gave form and consistency to the science during that whole period.

Mediæval.—The works from which our supplementary knowledge is derived are those compiled prior to the subversion of the Roman Empire. These have all a kindred form and spirit; they all more or less teach the doctrines of the Alexandrian school. With the irruption of the northern tribes, a new era of greater diversity commences. The ecclesiastical writers retain for a time the old impress, but it gradually wears off. The Jewish writers on geography retain it still longer; down to the thirteenth century we can trace Alexandrian learning in them. The Arabian writers are of the same school and time. Then come the writers of the age of our Mandevilles and Marco Polos, the credulous but graphic and inquisitive precursors of a better age.

In this period we have systematic writers who furnish us at once with a framework wherein to arrange whatever facts we can glean, and a key to the understanding of their language. We are less apt to be misled by dreams of cosmogony; for intellect is sufficiently advanced to allow even the minds most addicted to mystical pursuits to recognize their limits, and avoid carrying them into the field of geography. Towards the close of this period the sources become more numerous and varied; and a more extensive and careful study of national and individual character is necessary to enable us to estimate aright the value of the different pieces of information we receive from the writers of these times.

III. The revival of intellectual activity throughout Europe displayed itself with almost preternatural activity in the pursuit of geographical knowledge. The ancient classical authors were diligently studied and edited. Information collected from merchants and mariners, Christians and Mohammedans, was redacted and published. The art of map-making, pointed out by the Alexandrian school and improved by the Arabs, was sedulously practised. States and monarchs vied with each other in patronizing ingenious and adventurous men, who roamed through unknown lands and penetrated into unheard-of seas. The fruits of this busy industry were huge accessions of wealth, and continual fresh gratifications of curiosity concerning new lands; and in this busy time a man unequalled for his cool intellectual daring arose. The shape of the earth had been accurately enough inferred before his time; but although the learned yielded a theoretical assent to the problem, even with them it did not overcome the impressions of the senses. Beyond the ocean which had been found to wash the visible shores of all the known world, everything was dim conjecture. To venture out into the unknown, a region over which all the darkest and most fantastic shadows of imagination hovered, was an undertaking at the bare conception of which thought shuddered and the heart recoiled. One man was found with sufficient confidence in the inferences of science to adventure on a voyage which, however unexciting it may seem to us, must have been, on the first outset, second only in awful anxiety to the plunge into eternity. It was then, as it were, a launching out into infinite space. Christopher Columbus not only held the rudder of his bark as calmly on the mountain billows of the hitherto untraversed Atlantic as on the sunny sea of his native Italy, but kept within bounds at the same time the superstition and despair of his well-nigh frantic crew. He gained the reward of a truly heroic act of faith—success.

Almost contemporary with the discovery of the western world was that advance in physical science which has ever since kept pace with it. Galileo, Newton, Laplace, Herschel, and Leverrier have arisen in quick succession; Cook, Bruce, Humboldt, Livingstone, and Stanley have been equally indefatigable in their spheres of action. In geographical research and adventure the labourers have neither been few nor indolent. Not an instrument has science invented, not a new field of inquiry has she opened up, but travellers have availed themselves of the one or the other. Arcs of the equator and meridian have been measured. The mysterious indications of the magnetic needle have been followed up, until its declination and its dip have yielded their lessons. Commerce sent her pioneers. To these have succeeded, with higher and holier mission, but not with stouter hearts, the ministers of science and the missionaries of religion. No recorded time, any more than any given space, has escaped curious research. While our Franklins, Parrys, and Kanes have been exploring the amorphous arctic regions, where man yet crawls about, leaving no enduring trace behind, our Champollions, Niebuhrs, Riches, Woods, Schliemanns, and Layards have traversed the scenes of the early history of our race, to rescue from oblivion what yet remains of their handiworks, and to piece together and decipher the too scanty fragments of those records which have been discovered or unearthed amid the *debris* of "the dark rereward and abysm of time."

The works, more or less scientific in their nature, from which geographical knowledge may now be gleaned, are so multitudinous as almost to defy enumeration and classification. They are of very unequal value, but every year we can trace an improvement in them in point of accurate habits of thinking. The number of travellers who submit

the records of their experience to the public is continually on the increase. Milton, in framing an ideal system of education for the Commonwealth, proposed that that class to which even he, in his age, thought the advantages of systematic education must be confined, should travel, and on their return should submit a report of observations made during travel to government, and thus furnish additions to the national stock of knowledge and a test of their capacity for public employment. The establishment of a national system of education, the increased power and importance of public opinion, and the extended use of the press, is supplying what Milton wished, rather than hoped for. The number of our curious travellers far exceeds what he could have contemplated; the public voice is in last resort the acknowledged ruler; and the press is the means by which those who would serve this sovereign—the public—submit to his inspection their observations, deductions, discoveries, or suggestions.

The sources of our geographical knowledge are too fragmentary, incidental, almost accidental. Their aggregate results are, however, accumulating and increasing in value. We require ready and efficient means for making these results available, and an *ideal* in accordance with which to organize our geographical knowledge into a science. So lately as 28th September, 1859, Karl Ritter, the creator of scientific geography, died. In place of confining the idea of geography to a collection of isolated facts, and the presentation of them to the mind without any bond of union or association except that of their occurrence in a text-book, their contemporaneousness in time, or their connection in place, he strove to discover the inner and natural relations between the earth and its inhabitants. Citing his facts into the presence of the mind from all quarters and from every science, he sought to deduce from these, by rigorous induction and by vigorous logic, the most varied and important trustworthy conclusions which they appeared to yield, and so to institute a "Physiology of the Globe." He did not live to finish the mighty task he undertook, and which he foreshadowed in outline in "Geography in its Relations to Nature and Man" (1817–18), illustrated during thirty years in many massive volumes, and reasserted in his "Essay on the Study of Geography, and Memoirs on a more Scientific Method of treating that Science," in 1852. Of the old multifariously encyclopediac geographies, the best is perhaps that of Malte-Conrad Brun, the Danish-born secretary of the Geographical Society of France (1775–1826)—"The Geography, Mathematical, Physical, and Political, of all parts of the World." Of the higher and nobler geography of the new scientific school, we may cite as an example that gorgeous panorama of nature which F. H. A. Humboldt, in 1851, presented to the public in his "Cosmos; an Essay towards a Physical Description of the World." Similar work has been done by Mrs. Somerville in her "Physical Geography," by Matthew F. Maury, the American hydrographer, astronomer, and physicist, in his "Physical Geography of the Sea." The scientific ideal of geography has been carried on by Berghaus, in his "Critical Guide in the Domain of Geographic Science;" Arnold Guyot, in his "Earth and Man;" Henri Kiepert, in his "Historico-geographical Commentaries," and by A. K. Johnston, J. Morse, James Bryce, Dr. Bogecamp, Frederic de Rougemont, W. L. Gage, A. Geikie, George Grove, &c. These, together with Roon, Voelter, Wenzig, Etzel, Kotschy, Wappeau, Kloden, Nicholay, Sabine, Markham, Stanley, Thomson, &c., and their followers, have in all countries inspirited geography with new life and are expounding it in a scientific method.

Looked at in the scientific form which Ritter suggested, geography is both an extensive and an intensive study. It implies not only a wide and accurate knowledge of many varied facts, but also a close and diligent exercise of the reasoning faculties. It seeks to comprehend the causes of change, the course of law, the relations of phenomena, the results of intercourse and culture; the lessons of the seasons and of soils, of animal and plant life, of climate and atmospheric influences, of man's neglect and nature's spontaneity, of normal force and abnormal action; and it regards the entire life of the globe as an organic unit, simple in its complexity and complex in its simplicity.

The importance of geographical discovery to commercial prosperity has always been recognized. This was shown in the institution of the great trade guilds of the middle ages, which merged in their turn into associations of various sorts for the opening up of markets for exports and imports; such as The Mysterie Companie of Merchant Adventurers—established by Edward I., 1297, and instituted by Royal Charter in 1505—"for the discoverie of regions, dominions, islands, and places unknown," in which Sebastian Cabot held in 1548 the office of governor; and The Governors and Company of Merchants in London trading to the East Indies, formed under the stimulus of the successes of Drake, Cavendish, Raleigh, and others, who sent out (1582) James Stevens, the first Englishman who reached India by the Cape of Good Hope, and who were chartered by Queen Elizabeth, 1600. Another less formal body of merchants and gentlemen, interested in the intellectual excitements as well as the material benefits of geographical expeditions, was The Saturday Club, which, after many years' existence, merged in The African Association, 1788, under whose auspices and with whose aid many expeditions into the interior of Africa were made. But the time came when men felt the need of organizing and comprehending the vast array of accumulated facts; and while Ritter was laying the foundations of a geographical system philosophically, others were striving to attain the same end practically. The first geographical society was established in Paris, 1821; the second, The Royal Geographical Society of London, was instituted in 1830; a third was formed in Berlin, 1833, and since then similar associations have originated in all the capital cities of Europe, many of the large cities of America. the three presidencies of India, &c. The Scottish Geographical Society was founded in 1884. Their objects are all similar—(1) to collect, register, digest, and, where advisable, print accounts of new discoveries, &c.; (2) to collect a library of maps, charts, books, &c.; (3) to procure specimens of instruments, and to provide instructions useful for travellers; (4) to correspond with other similar societies; and (5) to encourage, aid, and reward geographical investigations, and diffuse a knowledge of their results.

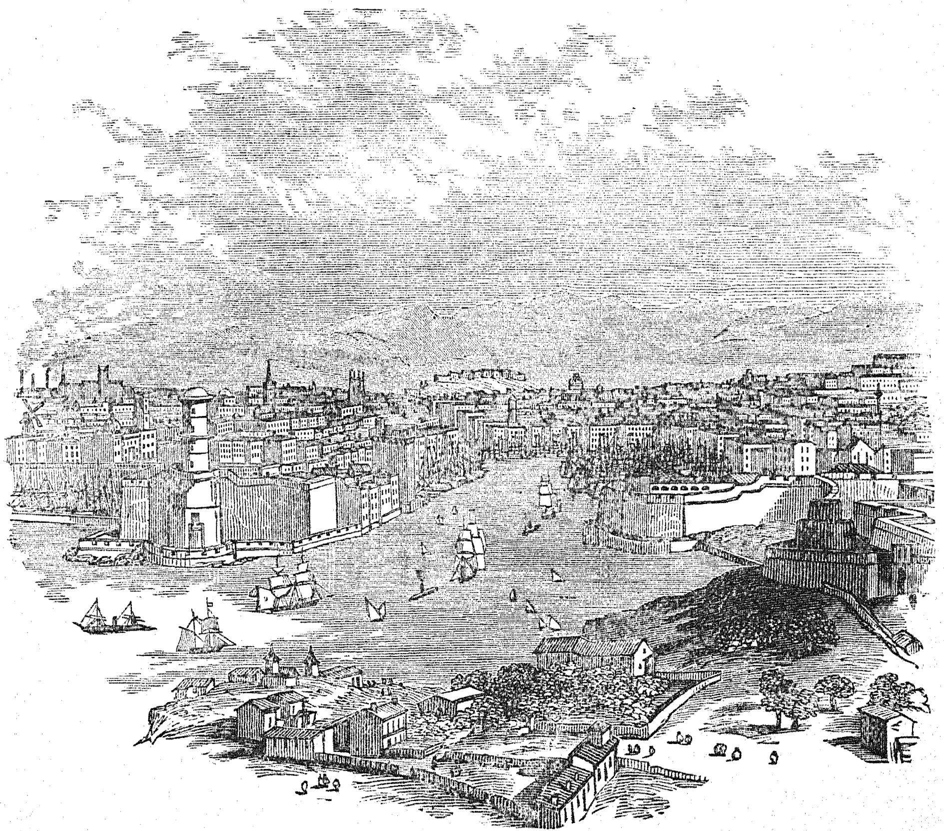
The interest felt by all circles of society in a knowledge of other countries has always led to the ready perusal of books of travel in which descriptive or scientific geography was kept in view. From the earliest times our fellow-countrymen have been distinguished for their zeal in visiting far-off lands, and seeing the strange sights of the globe. Age after age sailors, soldiers, merchant-adventurers, diplomatists, men of science, gentlemen at leisure and of means, have been engaged in surveys, explorations, excursions, travels, tours, voyages, &c and have brought or sent home the tidings of what they saw, learned, and investigated. In numerous books of many sorts, historical, descriptive, scientific, and political, there have been presented to the world sketches of cities, countries, districts of hill or prairie land, mountain passes and lowland valleys, sea-board or river-course, in all portions of the earth.

Geographers have collected from despatches, government papers, journals, diaries, travels, and sketch-books, the facts they narrated concerning the scenery and contour of places, and brought into our view the scattered notices which from time to time, and by different persons, have appeared in any authentic record, and so furnished a complete picture of the aspects of nature in every quarter of the globe. It has been no light task thus to collect, arrange, group, collate, and verify the various materials scattered through so many volumes, pamphlets, reports, &c. This, however, has been accomplished under the guidance of the inspiring idea of the great scientific geographer of Berlin. Every day the newspaper—"herald of a noisy world"—brings us news from all nations, parts, and places, and either excites or gratifies our curiosity concerning regions near or remote. Gazetteers and school-books have spread a knowledge of geography among all classes; geographical journals and the transactions of societies also keep a constant outlook on all that is new and singular in man's experience in or discoveries regarding the earth, its phenomena, inhabitants, and changes. Thus grows our acquaintance with the world in which we live, and the need of garnering the knowledge gained with so much toil.

THE FRENCH LANGUAGE.—CHAPTER I.

HISTORY AND ETYMOLOGICAL SOURCES OF THE FRENCH LANGUAGE.

FRANCE, in an age prior to historic records, was inhabited by a race of Aryan descent, which had come originally from Central Asia and spread over Europe. They were named Celts, and the language they spoke was Celtic. In early times some tribes sailed to Southern France from Phocæa—a town in Asia Minor nearly 25 miles north-west from Smyrna—settled there, and built (about 600 B.C.) the city of Massilia, now Marseilles.* They were a commercial people, and had engaged in trade with the Romans even while the latter formed part of a mere confederacy of Italian townships. About 121 B.C. the Romans sent out a colony to settle in the valley of the Rhone. The influence and power of the Romans increased, and ultimately, after a war which lasted eight years, Julius Cæsar (50 B.C.) reduced Gallia—as France was then called—to a province of Rome. Of the language and literature of the Celts of Gallia no specimens have been preserved, though we may fairly conjecture that both had received some culture and development; and that their literature of tale and ballad resembled that of other Celtic races. It was the custom of the Romans, when they had conquered



Marseilles

* THE FOUNDING OF MARSEILLES.

The inhabitants of the city of Phocæa, threatened with being invaded by the Despot of Persia, formed (took) the resolution of leaving to the enemy, so much stronger than they, nothing but the stones and the most perfect solitude. Accordingly the Phocæans, a maritime people, all embarked on board their vessels, carrying [with them] the most precious of the things which they possessed, their laws, their wives, their old men, and their children. They were willing (loved) rather to expose themselves to the dangers of the sea in its fury, than to bear the yoke of an unjust and ambitious tyrant.

The winds drove this fleet upon the coast of southern France. There they landed (disembarked). The olive and the vine in their hand, they all proposed to attempt a settlement there. They were very well received by the Salyes, the Tectosages [Volcæ], and other people of the sea-coast. These ceded a portion of it to them. They there laid out the foundations of the city of Marseilles, pretty nearly about the time of Tarquin the Elder, at Rome. The festival of the founding of this ancient city was remarkable for the form of the oath which they pronounced in the presence of the astonished Gauls.

The magistrate of this new republican colony, standing upright upon a [built] mound, threw into the sea a heavy anvil [made] of iron, while pronouncing these words, which were repeated every year at the same period: "The Marseillaise Phocæans will consent to become slaves when this mass shall rise again to the surface of the water, and shall float thereupon."

FONDATION DE MARSEILLE.

(600 ans avant Jésus-Christ.)

LES habitants de la ville de Phocée, menacés d'être envahis par le despote de la Perse, prirent la résolution de ne laisser à l'ennemi, beaucoup plus fort qu'eux, que les pierres et la plus parfaite solitude. En conséquence, les Phocéens, peuple maritime, s'embarquèrent tous sur leurs vaisseaux, emportant ce qu'ils possédaient de plus précieux, leurs lois, leurs femmes, leurs vieillards et leurs enfants. Ils aimèrent mieux s'exposer aux hasards de la mer en courroux que de supporter le joug d'un tyran injuste et ambitieux.

Les vents poussèrent cette flotte sur le rivage des Gaules méridionales. Ils y mirent pied à terre. L'olivier et la vigne en main, tous y proposèrent l'essai d'une plantation. Ils furent fort bien reçus des Saliens, des Tectosages et autres peuples de la côte. On leur en abandonna une partie. Ils y jetèrent les fondements de la ville de Marseille, à peu près dans le temps de Tarquin l'Ancien, à Rome. La fête de la fondation de cette ancienne cité eut de remarquable la forme du serment qu'ils prononcèrent en présence des Gaulois étonnés.

Le magistrat de cette nouvelle colonie républicaine, debout sur un môle, fit précipiter à la mer une lourde enclume d'airain, en prononçant ces paroles qui furent répétées tous les ans à pareille époque: "Les Phocéens Marseillais consentiront à devenir esclaves, quand cette masse remontera à la surface de l'eau, et y surnagera."

a country, to impose on its inhabitants, as far as possible, their laws, language, and religion. The higher and wealthier classes in Gallia, of course, found it their interest to learn to speak the Latin language. The Celtic natives soon got into the habit of using the speech of Rome, and, by neglect—except in a small district called Brittany in the west—the use of their own original language was almost forgotten; Latin superseded it.

The Latin language, as it was spoken by orators and written by authors, was closely-knit in its grammatical structure, and therefore very difficult in its inflexions and syntax to those who aimed at using it exactly. Even in Rome itself, the common people did not speak it with strict accuracy; and as the larger portion of the settlers from Rome were peasants, soldiers, sailors, and slaves, it was vulgar, colloquial rather than classical, Latin they introduced into France. It is from this Low Latin (as it is called) that the root-words of modern French are mainly derived. The *lingua rustica*, or rural speech, the language of the million, was specially the language of the Franks. The works of the poets Ausonius (309–392) and Sidonius Apollinaris (431–482)—natives respectively of Bordeaux and Lyons—and others, prove that classical literary culture was possible, however, even in this western part of the Roman Empire. For nearly 500 years the Romans retained their power in Gaul. After that, the Teutonic tribes who subdued Rome, overran its colonies also, and settled at different times in different portions of France. Gradually they became incorporated with the Celtico-Romanic population of the country, and were under the necessity of speaking the language in use in the districts of which they had taken possession. At length the Latin of literature passed away as a spoken language in Gaul, and the Romanic tongue of the many mightily grew and prevailed.

Gallia was divided into three districts, occupied respectively by the Belgæ in the north, the Celts in the centre, and the Aquitanians in the south. These had each specific differences in their mode of speaking. When the people of these parts were set free from the pressure put upon them by the colonists, soldiery, officials, &c., wielding Roman power and possessed of Roman love of, and ability to use, the language of Rome, they paid little heed to anything except being understood by one another; and even their vulgar Latin became less and less submissive to mode and rule. As similar forms of speech and of vocalization usually prevail among people of similar habits, associations, and ways, these provincially-related peoples took to a style of speech peculiar to themselves quite naturally. Five differing modes of speech, in course of time, arose among the people of Gallia—*First*, that of the districts of the Septimanie in the south. The climate and civilization there, resembling that of Rome, induced in them a pliant, musical, and powerful mode of speech, the vowel-sounds of which were rich and harmonious. This was called Provençal or the *Langue d'oc*—perhaps from German *auch*, also, used for "yes." *Second*, that of the Isle of France, a province inclosed by the Seine, Marne, Oise, and other rivers, formerly called Francia (the land of the Franks). Their civilization was less perfect and their life more austere. The language of this district was harsher and more nasal. It was called the *Langue d'oïl*—probably from German *wohl*, well; now *oui*, used for "yes." *Third*, Burgundian, that spoken over an extensive tract of South-eastern France and Western Switzerland, the chief towns of which were Geneva and Lyons. *Fourth*, Picardese, the form of speech employed in the north-west portion of France, lying between Dieppe and Calais. *Fifth*, Norman, a later style of language adopted by the immigrants or invaders from Norway, Sweden, and Denmark, who had made themselves masters of the land watered by the Seine from Paris to the English Channel. The three last-mentioned forms scarcely attained a literary existence, and were rather *patois** or dialects than languages. The second, as the speech of the Frankish chieftains and the kings of the Franks, established itself in the north and became the written language of the whole land. The Langue d'oc was a highly-poetical language, and through the sweet songs which the troubadours sang in it, attained much popularity; but when the sovereignty of the French monarchs overpassed the Loire, Provençal declined and became only a provincial form of French. From all these affiliated fashions of speech, however, France adopted more or less freely such words as were required to constitute a copious and well-arranged vocabulary, fitted for being a serviceable medium of intercourse. A few Celtic terms, which had been incorporated in the Roman language, hold a place in French; a good many Teutonic words—chiefly relating to war, the chase, and the social system—were also absorbed into it. Normandy provided a large number of apt and needful names having reference to the sea and naval affairs. The melodious poetical phraseology of the Langue d'oc supplied a varied choice of words associated with every-day experience, common objects, and social affections. The Crusaders, returning from the Holy Land, brought with them Jewish phrases and Hebrew terms; and the use of the sacred writings by the learned and the ecclesiastical added to this store. The popularity of Arabian science and philosophy during the middle ages also led to the adoption of a considerable number of words derived from the lexicon of these teachers of mathematics, alchemy, astronomy, metaphysics, &c.

* *Patois* is now in general use in European countries to denote that mode of speech which is peculiar to the lower—generally the more rustic—population of a nation. It is probably corruptly derived from Lat. *patria*, one's fatherland.

To pursue this matter to our own time, we may remark that the wars in which France has been engaged have necessitated the introduction of many Italian, German, Spanish, and even African words. Commerce and trade have been copious sources of supply. Learning and literature have opened up the treasuries of vocables in which the Greeks and Romans expressed their thoughts. From the master-pieces of modern foreign writers many verbal importations have been made. Inventions, discoveries, industries, arts, &c., have all added largely to the lexicographic wealth of the word-rich language of France.

The results of those historic changes whose causes have been but briefly stated, and of others of a similar nature perhaps left unnoticed in this concise sketch, have been gathered together and brought into one view. Of one of the best and handiest of these approximate estimates, that which is given in M. Brachet's "Dictionnaire Étymologique de la Langue Française," we subjoin the following adaptation as a tabular view of the common root-words in modern French:—

I. Words of origin unknown,		650	IV. Words of foreign origin:		
II. Words of popular origin. viz.—			(1) Italian, . . .	450	
(*a*) Latin elements (primitive), ...	3800		(2) Provençal, . . .	50	
(*b*) Teutonic (prior to 1500), . . .	420		(3) Spanish, . . .	100	
(*c*) Greek (not from books), . . .	20		(4) German (after 1500), . . .	60	
(*d*) Celtic (prehistoric),	20		(5) English, . . .	100	
		4260	(6) Slavonic, . .	16	
III. Words of historic and onomatopoeic origin.		145	(7) Semitic, . . .	110	
			(8) Oriental, . .	16	
			(9) American, . .	20	
					922
			Total. . . .		5977

In the best French dictionaries for ordinary use there are about 30,000 words given. The great mass of these have, however, been either introduced by the learned directly from Greek and Latin, or are formed from the few words enumerated in the above table as roots, by derivation and composition. The words reckoned by M. Brachet are in reality the working materials for everyday use in life and conversation in spoken French. The book-language of literature in France, as in all other countries, is that of the learned and of specialists who treat of matters requiring a phraseology of their own. A very small proportion of these latter terms requires to be known by the general reader, and even the familiar conversationist, instead of needing more than these, would find himself pretty well furnished for all practical purposes by little more than half as many as are noted in M. Brachet's table of the etymological elements of French.

The words and phrases which came from all these differing sources were, as far as possible, naturalized and incorporated into French. These were sometimes introduced with colloquial corruptions, accidental peculiarities, elisions, ab-

breviations, and even the vulgarisms of the time, tone, and spoken form. For a while the principles of vocalization were neither fixed nor unquestionable. Language was flexible and provincialisms struggled hard against the levelling tendency of a prevailing power. At length printing took the language into its care, and undertook to manage all orthographical matters. Words required thereafter to accept a settled form when written or printed. Custom took the force of law, and was established by grammarians. Speech, which had hitherto been fluent, became formal, and words were often spelled with letters redundant as to sound and useless in pronunciation, though sometimes materially requisite to indicate derivation and determine meaning. These, grammarians were content to regard as quiescent, and hence they became integral parts of the written language and confusing elements as regards pronunciation. To fuse these mixed elements into oneness was a work of time, and required the exercise of compromise and patience. Time, custom, and the gradual influence of example and education, in the long run, modified and moulded French into a clear, consistent, simple, and useful language, in which almost any form of thought may be furnished with an appropriate form of words. It is compact, varied, unconstrained, well-equipped with vocables, and capable of fine syntactic felicities.

The number and diversity of the foreign acquisitions made by the French language have not had any effect in changing its specific analytic character. The main elements of its lexicon are, as we have seen, Latin; but it has entirely abandoned in its grammar the synthetic mechanism and inflexions of the Roman tongue. This was, of course, effected gradually. In fact it was a concession to necessity. The people whom Rome conquered were ignorant of the well-defined declensions and intricate conjugations of classical literature. They looked on the carefully elaborated system of inflexions by which the Romans made word tally with word, so that the whole framework of a sentence should be firm and strong, as an intrusive encumbrance; and would have none of it. Nor did they know how, without them, to interlock their words and phrases according to the rules of the strictly disciplinary scholastic syntax. But intercommunication was indispensable. The Romans therefore endeavoured to comprehend the ill-connected, uninflected phraseology of the Gallic peasant or trader, while the latter on his part tried to acquire a knowledge of the root-terms of the Roman tongue, and, though unable to accomplish the interweaving of his words, naturally made eager efforts to express his desires in the root-forms usually employed by the Romans. The vocabulary thus acquired being accepted as the common source of their communication, there grew up between them a workable compromise, in which Roman words, in their crude form, constituted the main stock of their means of intercourse, while the near collocation of related words took the place of, and served as a substitute for, the sentence-building syntax of their Roman interlocutors. Ease and freedom gave added charms to this simple system. Both got habituated to it; and there grew up, out of this conventional convenience, the custom of stating their thoughts in words which had been deprived of defined declension-forms and syntactic subtleties.

In the lapse of years all sense of laxness of structure disappeared, and soon the taste natural in man for making his conversation sweet and pleasant to his associates led to the exercise of some artistic arrangement of words. Men began to notice, classify, and imitate the nicer modes of collocating phrases. Those rememberable forms of expression which charmed by their grace and felicity were first chosen as patterns, and next taken as regulative examples. They then came to be looked upon as imperative forms of speech, the observance of which was indicative of the possession of a mastery of the language. These have now been accepted as models, and directions for imitating them have been arranged into a series of rules which govern spoken and written French, and form the syntax of that language in polite society and among cultured people. French is read, written, and understood in conformity with these rules by all natives, even when they speak it provincially among themselves. There are *patois*, it is true, like the Gascon, Limousin, Languedocian, and Provençal in the south, and the Normandic, Picardese, Lorrainese, and Burgundian in the north, which are spoken and listened to preferentially by at least the rustic populations of these districts. Even in places not very widely separated from each other geographically, there are slight perceptible differences of pronunciation and phraseology which indicate provincialism, though they do not imply dialectic distinctions. Uniformity of phrase, intonation, and accent are not possible in a land where the territory is so extensive, amid conditions so different, and among people derived from such mixed races Paris exercises a prevailing power in fashionable pronunciation, and yet, even in metropolitan circles and among well-educated professional people, minute variations may readily be detected which indicate, to the well-informed, provincial birth or upbringing, or some other accident of training and position.

It is easy, from our own experience to understand how the peasantry of ancient France should fail to note and reproduce the inflexions of the Latin language, when they fell at once on unaccustomed ears and unprepared minds. The ordinary ear is appreciative of common sounds, and finds it difficult to catch and realize fine and delicate changes in words having a general similarity of sound. Without a correct report from the ear, the tongue cannot reproduce them. The consequence is, that the general body, as it were, of the sound is that which affects the ear and is given to the tongue for utterance. In this way, we see how, while the main roots of words were registered in memory, the inflexions were neglected. In any refined speech introduced among a rude people, such a phonetic disregard of delicate peculiarities is sure to occur; and that happened in the transition period of the Roman rule and the formation of the Frankish confederacy. Necessity thus (1) enforced the suppression of inflexions, (2) brought about the abolition of declensions, and (3) led to the contraction of words. These contracted popularly-formed words—which constitute, one might almost say, the everyday spoken language of France, as distinguished from the written or bookish vocabulary of French literature—are, though originally of Latin descent, considerably different in appearance from their classical ancestors. The eye scarcely recognizes, and the ear has some difficulty in perceiving, in the words *blâme*, *clarté*, *esprit*, *feu*, and *oracle*, the lineal descendants of *blasphemium*, *claritatem*, *spiritus*, *fœnum*, and *oraculum*.

It must be remembered that the case-endings of Latin declensions were not accented. In every word of more syllables than one, one syllable is accented and so made impressive to the ear. Such a syllable, even when the ear was least acute, must have attracted notice, and would have the power of making itself felt. Whatever else was unheard or faultily caught up, this was unlikely to be, and hence we find in the popular, as distinguished from the literary, Latin roots of the French language, a strong tendency to abbreviation, arising from the negligence of the inflected syllables, as in *accessus*, *accès*, access; *castellum*, *château*, castle; *frigidus*, *froid*, cold; *mercatus*, *marché*, market, &c. Almost always in words the strongest and best meaning—all their *raciness* in short—is to be found in their roots. When we know these, we have a clue to all else that they can signify. With these properly planted in the soil of thought, under fitting training and culture we can make new secondary and suggestive meanings shoot out and blossom from those vital roots. In this way language can give life to the objects of sense, and embody the very abstractions of mind. We can bring an idea within the scope of *perception* or *sous les yeux de l'esprit*, using in the one case a transplanted philosophic exotic, and in the other an easily understood metaphor. In this way the common wild flowers of the hedgerows may be brought, by imagination, into the garden of expression, and grow up, from the old stock, into forms of grace and beauty, in which they can scarcely be recognized as growths from the same root. The original and the transferred sense are equally well understood, though the one is comprehended by sense, the other by imagination. Thus *arbre* (*arbor*, a tree) means tree, beam (of wood), and mast; *côte* (*costa*, a rib), a rib, slope, or declivity; *diète* (*diaita*, mode of life), food, diet, arbitration, an assembly of princes; *flamme* (*flamma*),

flame, blaze, streamer or pennon; *goût* (*gustus*, a slight portion partaken of), relish, liking, fancy, taste.

In the early period of the formation of the French language Low Latin was almost unconsciously adopted and absorbed into the colloquial vocabulary. In later times, when Latin was consciously employed, it was subjected to less change. It was affiliated with more formality, and there was less loss of family likeness. The former were naturalized by the *paysans*, the latter by the *savans*, and sometimes we have double derivatives from the same source, the one antique and home-bred, and the other modern and acclimatized, as *comput* and *compte*, from *computum; métier* and *ministère*, from *ministerium; blâme* and *blasphème*, from *blasphemium*, &c. French was spoken in England side by side with the native tongue till the reign of Edward III.; in Italy, Dante's tutor, Brunetto Latini, speaks of it as "a delectable language, and more common than most others." Then came the revival of letters and the invention of printing. At length, about the beginning of the fifteenth century, the Langue d'oil had developed into what is now the French language. All trace of Romanic syntax disappeared, and the form of the language settled into individuality and independence. Since the beginning of the seventeenth century, but especially since the establishment of the French Academy by Richelieu in 1635, the French language has remained pretty much as it is at present. Its orthography has undergone some modifications and changes, and its syntax has acquired greater nicety and precision; but no important revolutionary alterations have occurred in it. Styles of literature have risen into vogue and fallen out of it; but conversational French has been, on the whole, very similar in its principles and peculiarities from the age of its formation until now.

The very slight sketch which we have given of the origin and progress of the French language will prepare the reader for finding (1) that a large portion of its root-words are already known by sight to us—such as capable, fable, noble, visible, education, opinion, religion, distance, évidence, force, vice, doctrine, famine, machine, scène, content, diligent, prudent, &c.; (2) that with a little attention paid to the laws of change in sounds we are likely to be able to recognize many words, even though they may have altered their appearance—as *clémence*, clemency; *docteur*, doctor; *faveur*, favour; *gloire*, glory; *humanité*, humanity; *militaire*, military; *tragédie*, tragedy, &c. Besides these a considerable number of words in common use are, with slight differences, very similar in English and French. The following may be given as examples:—

Abundant, *abondant;* access, *accès*, m.; actor, *acteur;* additional, *additionnel;* address, *adresse*, f.; admiral, *amiral;* advance, *avance;* advantage, *avantage*, m.; amiable, *aimable;* apartment, *appartement* m.; artizan, *artisan;* atom, *atome;* attack, *attaque*, f.; ball (dancing meeting), *bal*, m.; ball (for playing), *balle*, f.; bark, *barque;* brooch, *broche*, f.; butcher, *boucher;* brilliant, *brillant;* calumny, *calomnie*, f.; cane, *canne*, f.; card, *carte;* cannon, *canon*, m.; casket, *casquet;* chain, *chaîne*, f.; cord, *corde*, f.; contentment, *contentement*, m.; coffee, *café*, m.; crab, *crabe*, m.; crystal, *cristal*, m.; civilly, *civilement;* a count, *un comte;* cotton, *coton*, m.; dance, *danse*, f.; debt, *dette*, f.; defence, *défense*, f.; design, *dessein*, m.; desire, *désir;* dinner, *dîner*, m.; dependent, *dépendant;* doubt, *doute*, m.; enemy, *ennemi*, m.; error, *erreur;* example, *exemple*, m.; to exaggerate, *exagérer;* to embrace, *embrasser;* frank, *franc;* gallant, *galant;* grace, *grâce;* galley, *galère;* guard, *garde*, f. m.; herb, *herbe;* honour, *honneur*, m.; heroine, *héroïne;* honest, *honnête;* Ireland, *Irlande;* language, *langage*, m.; litter, *litière*, f.; literature, *littérature;* literal, *littéral;* mask, *masque;* mount, *monter;* medicine, *médecine;* manner, *manière*, f.; mile, *mille*, m.; marriage, *mariage*, m.; mason, *maçon;* companion, *compagnon;* party (resolution), *parti*, m.; pure, *pur;* perfume, *parfum*, m.; practice, *pratique*, f.; principle, *principe*, m.; principally, *principalement;* rank, *rang*, m.; rampart, *rempart*, m.; reason, *raison;* reflection, *reflexion*, f.; resemblance, *ressemblance*, f.; remonstrance, *remontrance;* resentment, *ressentiment;* to restore, *restaurer;* rhyme, *rime*, f.; round, *rond;* saffron, *safran*, m.; salad, *salade;* salute, *salut*, m.; savage, *sauvage;* sovereign, *souverain;* success, *succès*, m.; sum, *somme*, f.; to solicit, *solliciter;* soil, *sol*, m.; throne, *trône*, m.; valiant, *vaillant;* virtue, *vertu*, f.; virtuous, *vertueux;* verb, *verbe*, m.

The following abstract of a few other classes of words will show that a great many French vocables are already familiar to the reader:—Latin words ending in (1) *alis* give words in English and French by dropping *is*, *e.g.* annal, cérébral, final, matrimonial, natal, original, sacerdotal, vital; (2) *abilis*, *ibilis*, and *ilis* by changing *is* into *e*, *e.g.* affable, capable, navigable, variable, divisible, possible, sensible, agile, fragile; (3) *aculum* changes *um* into *e*, as miracle, oracle, spectacle; (4) *egium* and *itium*, *ium* into *e*, as collége, cortège, privilège, sacrilège, artifice, édifice, orifice, sacrifice; (5) *udo*, *o* into *e*, altitude, habitude, multitude, plénitude; (6) *itia* and *entia*, *tia* into *ce*, avarice, notice, justice, présence, absence, existence, science; (7) *ina* and *ura*, *a* into *e*, doctrine, machine, médecine, cure, figure, nature, obscure; (8) the accusative endings *antem*, *entem*, *ionem*, drop *em*, commandant, descendant, indépendent, agent, client, excellent, intelligent, opulent, accession, convulsion, infusion, information. Latin words ending in (9) *tas* make English words in *ty*, and form French ones in *té*, liber-tas, liberté, liberty; sagaci-tas, sagacité, sagacity. (10) *Osus*, which becomes *ous* or *y* in English, makes *eux* in French, copiosus, copieux, copious; generosus, généreux, generous; spongiosus, spongieux, spongy; odiosus, odieux, odious; vaporosus, vaporeux, vapoury. (11) Latin adjectives ending in *idus* often drop *us* in English, and in French change *us* into *e*, avid-us, avide; frigid-us, frigide; valid-us, valide; (12) *ivus* becomes *ive* in English, and in French *if* (masculine) and *ive* (feminine), activus, actif, active; captivus, captif, captive; (13) *arius*, *orius*, in English give words in *ary* and *ory*, in French in *aire* and *oire*, as contrarius, contraire, contrary; ordinarius, ordinaire, ordinary; armorius, armoire, armoury; (14) *anus* and *ianus* change into *ain* and *ien*, as hum-anus, humain; traged-ianus, tragédien. In this way, by observing the etymological sources of words, the vocabulary of our French may be very largely and easily increased.* On reflection, too, we could scarcely avoid inferring (1) that a good many phrases and incidental expressions, or forms of expression, have survived from past ages and got incorporated, as idioms, into the speech of the common people; and (2) that in a country of such extent, having undergone so many changes at different times and in various places, there must be, as we have seen there are, numerous varieties of dialect and some tendency to provincialism of pronunciation.

French is now spoken in France, Belgium, the Channel Islands, Savoy, the western parts of Switzerland, and Germany; in the foreign settlements of France—Algeria, Guiana, Senegal, New Caledonia, &c., as well as in Canada (which was formerly a French colony) and the Mauritius. In Brittany about one-half of the people speak *Bas-Breton*, a language of Celtic origin; in the northern parts *Flemish*, a derivative from Low German, is used by about one-fifth; a corrupt German is the language of the Rhenish provinces; two-thirds of the inhabitants of the Eastern Pyrenees employ a Spanish Low Latin dialect, called Catalonian; and in the Lower Pyrenees an antique tongue, of unknown origin, is the common speech of about a fourth of the population.

CHAPTER II.

THE ELEMENTS OF PRONUNCIATION.

PRONUNCIATION is the production of certain sounds, either singly or in series, in a distinct, precise, and well-understood

* For readers who do not know Latin the gist of the foregoing lists may be given briefly thus:—(1) A large number of words are alike in English and in French, especially of those which have the following terminations—viz., *ace, ice, acle, ade, ude, ure, al, ance, ant, ence, ent, ble, ile, ule, ine, ion, ge*, as grace, trace; caprice, malice; miracle, obstacle, spectacle; cavalcade, escalade, sérénade; prélude, solitude; future, tenure; minéral, vertical; ignorance; constant, distant; résidence, silence; evident, indolent, insolent; sociable, variable; reptile, textile; granule, mule; doctrine, machine; conviction, nation, solution; page, rage, sage, &c. (2) Many English words ending in *ary, ory, cy, ry, ty, or* and *our, ous, ine*, and *ive*, become French by changing these terminations into *aire, oire, ce, rie, té, eur, eux, in, if*, as notary, *notaire;* contemporary, *contemporaire;* arbitrary, *arbitraire;* glory, *gloire;* clemency, *clémence;* decency, *décence;* fury, *furie;* beauty, *beauté;* liberty, *liberté;* error, *erreur;* honour, *honneur;* dangerous, *dangereux;* outrageous, *outrageux;* clandestine, *clandestin;* attentive, *attentif*, &c.

manner, in accordance with the practice of the best speakers of a language. The organs of speech are normally similar in all races of men; and though there are varieties in their way of speaking and in the sounds which, in an ultimate analysis, the alphabets of different languages present as the elements of their words—because the power of producing special sounds is possessed by certain organs—the utterance of any desired sound ought to be secured by the placing of the organs of speech in precisely the same position as those do who speak any language as their native tongue. In all speech three things simultaneously strike the ear—sound, tone, and time. In each of these matters, every language agrees in much with others, and, from them, each also differs in certain peculiarities. If we can gather together all the elements in which our own language agrees with any other we may wish to learn and use, we shall have a certain amount of available knowledge to employ in and apply to our studies in that language. If, also, we can collect all the differences together and classify and arrange them in an order such that we may proceed in our endeavour to master them, from the simpler to the more difficult—that is, from those which are most nearly allied to our own usages of speech to those which are more remotely so—we should be able to set our whole mind earnestly, yet hopefully to making progress from the known and managed to the unknown but manageable. If we could get hold of some such plan, there ought to be little real difficulty in acquiring such a practical system of pronunciation as would enable us to imitate fairly the native population of France in their usual mode of conversational speech. No difficulty relating to oral speech can, it is true, be entirely removed or overcome by written explanation; but it is possible to give such directions, explanations, and observations as may furnish, to attentive and earnest students, the means of realizing to themselves the precise and definite points requiring note, practice, and familiarity. It is believed that, pursued with care, zeal, and attention, the following instructions will secure a fair and useful style of speaking and reading French fluently and well.

One of the greatest difficulties in learning any language, in an age of books, and especially when the student pursues his task by means of a book and without the aid of a master, is that we tend to learn by the eye rather than the ear. We accustom ourselves to attach the meaning of each word with which we become acquainted to its visible form rather than its audible sound. Hence we are able to read much more quickly, easily, and accurately than we can speak or write. We find ourselves quite puzzled by a sentence spoken or a question asked by the living voice, which would give us no trouble if we saw it in type or script. It is made by us more an exercise of the intelligence than of the memory and the tongue. We ought to endeavour to correct this tendency towards translation by the eye. This may in part be arranged by the committing of words, phrases, and sentences to memory, and repeating them (without verbal translation) so frequently as to be able both to produce the sound with the voice and to recognize it by the ear.

Familiarity with words in a book is only a small part of what we should aim at, even although our chief end in studying a language may be to enable us to come into direct contact with the minds of its great writers, and we may never expect to visit the land in which it is spoken or to use it for conversational purposes. To know a language thoroughly we require to learn to think in it, not merely to translate into it. If we wish to make the study of French a useful and agreeable pursuit we should try to take pleasure in transferring our ideas from their English outward form, and to give them a French dress. This should be done by realizing the words not only in the mind, but to the ear and the eye. Great benefit may be derived from the habit of naming the objects around us, wherever we are, and expressing their qualities in French; from converting our common thoughts into French phrases, and from the repetition of choice extracts from the best authors in their original form, until the sounds flow readily from the lips, are caught up easily by the ear, and translate themselves not into English words, but into pure thought. In reading French we ought to translate as much as possible in the mind, and not by audible phraseographical reproduction.

As regards pronunciation, which has been supposed to be an insurmountable difficulty in the case of the French language, it may be as well to remember that in it, as well as in every other language, there are really three styles of it—(1) conversational; (2) reading; and (3) oratorical. These have not been kept so distinctly before the mind in the teaching of French as they ought. Many, of course, desire only to learn to read French, and do not expect to have any occasion to speak it as a common medium of conversational intercourse. To those a great deal of the grace, dexterity, and *finesse* of spoken French is of little value. In books, an author is considered bound to express his ideas in due literary form. He is supposed to have time and opportunity for taking care and making choice, and therefore more regard to accuracy of language and precision of syntax is expected of him, as an artist in words, than from an improvising conversationist. In the reproduction of an author's words, in reading, we occupy, as it were, a representative position, and hence we ought to read in general with sustained staidness, expressive clearness, and intelligent effectiveness. A reader is not allowed the latitude of conversation, nor are the lighter, airier, and more relaxed forms of the colloquialist expected of him. His pronunciation ought to be pure, attractive, and correct, but it need not be finically fastidious. Oratorical speech is more ornate, demonstrative, and while free in construction, requires to be fluent, distinct, and measured in pronunciation. It is a well-established fact that, in all languages and in all grades of society, the structure of sentences is less precise and marked in conversation than in reading, and that there are niceties of phrasing and pronunciation in colloquial speech which are not usually reproduced in books, unless these are avowedly composed to reproduce representatively real or imaginary conversations. Attractiveness, sweetness, immediate influence, are aimed at in conversation, and under the impulses of sympathy of feeling the more rigid restraints of grammar and the stricter requirements of enunciation are, to a certain extent, allowably disregarded or dispensed with. Here there is no law but the custom of society, and hence colloquial French really differs not only at different times, but in the different ranks of social life. Of course, the best French is spoken by the higher and more cultured classes; and all who wish to talk with propriety and fluency try to catch, imitate, and reproduce their intonation and style. French conversation, in its high artistic form, is an inspiration rather than an acquisition. It is a fine art, and its adepts are not unfrequently able "to snatch a grace beyond the reach of art." To this height of perfection only a few attain. All the French themselves do not reach it. In fact, no art can create (though it may train, guide, correct, and encourage) a true artist. Necessity imposes upon all the acquirement of some power of transferring thought, feeling, intention, desire, and wants from his own mind to that of another (or others); but even that pregnant "mother of invention" does not produce in him the pliant ease, the flexile grace, the adroit versatility of phrase which impart vivacity, pleasantness, charm, and witchery to the conversation of the upper classes in polite society.

Most people find that they must, at first at least, limit their ambition to the attainment of ability to pass thought along in plain, easy, and familiar forms—of understanding and being understood. After this is accomplished, it is right to strive, by felicity of phrase and turn of thought, by aptness of word and skill in arrangement, to add the charm of art to the interest of communication. But a plain, straightforward mode of expression will find its way into another's mind though it may want the gayer adornment of the art of the fashionable circles, and a direct, pointed, correctly expressed question will convey its meaning and receive attention though not couched in the choice phrase of the *beau-monde*. The light, airy, tripping niceties of the *salons* are not easily attained, even by the French; but to speak French as they do in the ordinary, civil, everyday interchanges of courtesies and sentiments, is an attainment not beyond the reach of an ordinary, earnest, sensible student who takes pains and gives diligence. The eye, the ear, the tongue, and the mind must enter into cordial co-operation. The eye must suggest to the ear the sound which would represent each word

presented to it or reproduced by the tongue, while the mind takes in its meaning. What the ear hears, it must not only communicate to the mind, but suggest as sound to the mind and as form to the eye. What the tongue utters must not only come from the mind as words, but must suggest to the eye a true orthography, and to the ear a correct sound. This co-suggestive capacity is the secret of acquiring conversational French. Habit will soon make the process easy. The partnership in association must, of course, be mutual, real, ready, and lively. Then the power of thinking in French will secure the ability of speaking in French.

A fairly fluent conversationist may make his way without much observation if he employs the current phraseology of society, and adopts without emphasizing the intonation of the company with which he mixes. It is in a great measure the hesitant, embarrassed air of self-consciousness, in making use of an unusual mode of communication, which betrays the unpractised tongue and the unused ear, and not deficiency in deftness of oral tone or choice of phraseology. There are unique felicities, delicate shades of phrase, and specific idioms which few can master and manage with a native's accuracy and intuitive readiness; but it is the experience of every visitor to the Continent, that few people are more tolerant of slight differences or failures in tone, phrase, or expression than the French. They are very considerate in their sympathy with those who seek modestly to take part in the conversation of the day, and exceedingly ready by suggestive yet unobtrusive indications to make the unused tongue feel easy at its task. Any moderately fair approach to current phraseology, even though bookish and stiff, is graciously received, and no stare of astonishment turns the flash of a detective-like eye upon any one who makes his meaning clear in terms, even though he may not have caught up the airy grace and facile fluency of tongue which distinguishes the intonation of the highest circles of Parisian society. The compliment of care in study and of anxiety to share the responsibilities of social intercourse is kindly repaid by the encouragement of smiling guidance and skilfully given help.

Words are represented by letters to the eye and by sound to the ear. These letters are of two sorts, *sonant* and *consonant*. Sonant sounds are formed by the passage of air (breath) through the organs of speech. They are called *vowels*. Sounds which cannot be pronounced without the aid of vowels are called *consonants*. The letters which represent them are the same in *form*—though not exactly in sound—as in English, except that W and K do not occur in any native French word. Consonants are, in reality, less signs of specific sounds than of particular positions in which the organs of speech require to be placed while sounds are passing through them. In almost all European languages the normal positions of the oral organs are essentially the same. Hence the alphabets are practically, in a great measure, similar. In French, however, the consonants are much more strongly articulated than in English. Learners should notice particularly (1) the class to which each consonant belongs, (2) the place it holds in that class, (3) the position taken by the organ employed in producing each sound, (4) the sound produced. The following is a

CLASSIFIED TABLE OF THE CONSONANTS.

	Flat	Sharp	Liquid
1. Labial or Lip-letters,	B V	P F	M
2. Dental or Teeth-letters, ...	Z	S or C (soft), Ç	—
3. Lingual or Tongue-letters, ...	D	T	L N R
4. Palatal or Palate-letters, ...	J or G (soft)	C (hard) K or Q CH	—
5. Guttural or Throat-letters, ...	—	G (hard) H aspirated	—

6. X is a double-letter = KS or GS.

EXAMPLES.

1. Ba, Pa, Ma; Ba-by-lo-ne, Pa-pa, Ma-man. Va, Fa; Va-se, Fa-ce.
2. Za, Sa, Ce, Ça; Za-nie, Sa-ge, Ce-ment, De-ça.
3. Da, Ta, La, Na, Ra; Da-me, Tan-ne, La-beur, Na-me, Ra-me.
4. Ja, Gea, Ca, Ka, Qua, Ch; Jam-be, Geai, Ka-li, Qua-li-té Cha-os.
5. Ga, Ha; Ga-le-rie, Ha-sard.
6. Xa-vi-er, A-xi-ome, Ex-em-ple.

These consonants, as initials, produce similar sounds to those given to the same letters in English, only that they are somewhat more firmly made; but as finals, they are for the most part silent, or only pronounced when followed by a word beginning with a vowel, to which they can be carried over. See *Liaison*, p. 26.

The following notes on certain peculiarities will be found useful hereafter:—

B final is pronounced in proper names, as *Job*, and in *club*, *rumb*, a point of the compass, and *radoub*, the refitting of a ship. In *Sabbath*, *rabbin*, and *abbé*, each *b* is sounded; in all other cases *bb* is pronounced as *b*.

C (as in English) is hard, like *k*, before *a*, *o*, *u*, and *l*, *n*, *r*; but like *s* before *e*, *i*, *y*, and when preceded by a cedilla (ç), which denotes softness, as in *ce-ci*, *ce-la*, *gar-çon*, boy, waiter. When we wish to make *c* hard before these vowels it is changed into *qu*, as *public*, *pu-bli-que*; *vain-cre*, *vous vain-quez*; *c* sounds *g* in *second* and its derivatives. *Ch* sounds as *sh* (unless in imperfectly naturalized words); it is pronounced *g* in *drachme*, and is silent in *al-ma-nach*. It is very seldom sounded or carried over as a final.

D final is heard in proper names, as *David*, and in *sud*, south. When it ends a word connected with the next in meaning, and that word begins with a vowel or *h* mute, *d* sounds as *t*, *profond abîme* (pro-fon ta-bî-me), *grand homme* (gran t(h)omme), *en-tend-il* (en-ten-til).

F final is not heard in *clef*, *clefs* (klay), key, keys; *cerf* (ser) stag; almost everywhere else it is sounded, as in *œufs*, eggs.

Gn initial retains its sound; medial it sounds as *n*, followed by *ye*, as *règne* (ren-ye), *agneau* (an-yeau), *gagner* (gan-yay), *Sévigné* (Sĕ-veen-yay); and final it is pronounced as *k*, *bourg*.

L final is sounded, except in a few common words, *baril*, *chenil*, *cantal*, *fournil*, *fusil*, *gril*, *outil*, *persil*, *soûl*, *sourcil*. In *gentil*, idolater, it is sounded, but in *gentil*, it is liquid (gen-tee-ye).

L liquid is a peculiar sound given to *il*, *ill* (when not a compound of the Latin prefix *in*), which as nearly as possible resembles that of the *ill* in brilliant when the sound of *l* is omitted or very gently heard. It may be represented by *ee-ye*.

EXAMPLES.

Che-nil-le, *che-vil-le*, *pa-pil*, *bou-quil-le*.
Caterpillar, ankle, butterfly, skittle.
Bou-teil-le, *cor-beil-le*, *so-leil*, *a-beil-le*.
Bottle, basket, sun, bee.
Deuil, *seuil*, *fau-teuil*, *feuil-le*.
Mourning, sill, armchair, leaf (sheet).

Q initial is only used with *u* after it; final *q* in *coq* and *cinq* sounds *k*.

R is pronounced like *rr* in English *err*.

S between two vowels is pronounced as *z*; *s* before *c*, followed by *e*, *i*, or *h*, is not heard, as in *scène*, *scé-lé-rat*, *schisme*.

T final is generally unheard; but is sounded in *brut*, rough; *dot*, portion; *fat*, coxcomb; *est*, east; *ouest*, west.

Ct is sounded in *tact*, *exact*, *direct*, *correct*, *abject*, *suspect*, *circonspect*; but is not pronounced in *aspect*, *respect*.

Z final takes the sound of *s*, except in the second plural of verbs, where it preserves its own sound, if followed by a word beginning with a vowel.

There is a difference in their system of syllabification between the English and the French, attention to which will help greatly towards simplifying the acquisition of a correct pronunciation. The French rule is that, if at all possible, each syllable should begin with a consonant, e.g. *a-na-ly-tique*, not as in English *an-a-lyt-ic*. Should two unlike consonants come together in the middle of a word they are in general separated, but the following combinations of letters, *bl*, *cl*, *gl*, *pl*; *br*, *cr*, *dr*, *fr*, *gr*, *pr*, *tr*, *vr*; *ch*, *th*, and *gn* (when nasal), are regarded as single ones, e.g. *ai-ma-ble*, *o-ra-cle*, *ai-gle*, &c.; but double consonants are generally pronounced as single ones, and as if attached to the succeeding syllable, e.g. *bai-sser* (bay-zay), *to-nneau* (tŏ-nō), &c. There occur here these exceptions, viz. *cc* before *e*, *i*, or *y*, though

alike in form are unlike in sound, and so are separated, as *ac-ci-dent* (ak-see-dan); *ll*, *mm*, *nn*, and *rr*, when the former is the closing letter of prefix and the latter is the first of a root, are separated, as *il-le-gal*, *im-mor-tel*, *in-nom-bra-ble*. It is very difficult for English speakers to manage such words as *terre*, *lettre*, *ombrelle*, *hirondelle*, &c., and perhaps the best plan is to pronounce them thus, *ter-rĕ*, *lettr*, *om-brel-lĕ*, *hi-ron-del-lĕ*, sounding the consonant but not the last vowel.

In French, the accent is always put on the last syllable, if it is pronounced at all, and on the penultimate if the last syllable is mute; and it is much less strongly marked than in English (or German). It is, indeed, sometimes asserted that there is no accent in French; but the best modern authorities, as Littré, teach that, in reading French, each syllable should be distinctly pronounced, but that a slight stress requires to be put on the last syllable requiring to be expressed, as *ir-ré-gu-li-er* (eer-rĕ-goo-lee-ay). When the French say that anyone has no accent, they mean he has no provinciality of pronunciation, but speaks properly, *i.e.* as a cultured Parisian would do.

Accent, as a technical term in grammar, has quite a different signification. Accents are signs placed over vowels, either (1) to indicate their proper pronunciation, or (2) to distinguish words which are similarly spelled from one another. There are three accent-signs, (1) acute, as in *vérité;* (2) grave, as in *père*, *prophète;* (3) circumflex, *pôle*, *rôle*, *dû*, *crû*, &c.

In order that we may speak distinctly and agreeably, the mouth must be opened slightly so as to allow a clear, smooth, sonorous flow of sound to pass easily between the two rows of the teeth, in a free, full, and pure tone. To acquire this easy and graceful fluency of utterance it is advisable to practise carefully the enunciation of the vowel *o* with the full open sound of the English word *owe*. To do this effectively, fill the chest to its utmost capacity with air, and let it glide through the voice-organs at first slightly, softly, and clearly, but continuously keeping the same tone; next in a louder and fuller form, so long as the breath can sustain sameness of utterance; and then, expressing the self-same sound as fully as the voice is able, keeping the breath in an equable and gradual process of expiration. After this try to take the same sound through the whole range of the powers of the voice, from the lowest to the loudest, and *vice versâ*, preserving the sound pure and unarticulated, *i.e.* without making any movement of the vocal cavity, and making the whole difference of tone depend on the quantity of air expired. *Co-co*, *mo-no-tone*, *lo-co-mo-tive*, *mo-no-pole*, *fo-li-o*, *nu-me-ro*, will supply examples and exercise.

As the next exercise open the mouth well, but do not let it be unnaturally stretched, and pronounce through the orifice thus made the sound *a*, like the exclamation *ah!* or the sound given to *aa* in the word bazaar. This sound should come freely, fully, and richly from the back part (pharyngeal) of the mouth, and be sustained in equal quality and pitch as long as possible. After acquiring readiness and fullness of production, pronounce the following words slowly, syllable by syllable, sustaining at first the sound of each syllable as long as possible with precisely the same kind and degree of enunciation of the *ā* sound:—*Pa-pa*, *Ca-na-da*, *a-na-na(s)*, pine-apple, *a(p)-pa-ra(t)*, show, *ar-ca-de*, *pa(s)-sa-ge*.

As regards the vowel sounds, the learner will find that at present the following table will suffice for practical purposes:—

TABLE OF VOWEL SOUNDS.

û and u	=	oo, as in *spoon*, but shorter, and a little like *ew* in *stew*.
î and i	=	ee, as in *feet*.
i (sometimes)	=	ĭ, like *i* in *pin*.
ê and è	=	ay, as in *pay*.
é (final)	=	ay, as in *pay*, but shorter.
é and e	=	ĕ, or *e* in *trespass*.
e final is not sounded.		
ô	=	ō, or *o* in *dole*.
o	=	ŏ, or *o* in *rot*.
â	=	ah, or *a* in *ardent*.
a	=	ă, or *a* in *salary*.

The following paragraphs explain some of the refinements in sounding the vowels. Although they need not be committed to memory at present, they should be read carefully and referred to frequently during the study of the subsequent chapters.

A sound which is of great importance, and requires much care to produce it properly, is that of *u*. This is done by placing the lips almost in the position in which the English interjection *whew* is enunciated—with the lips a little more protracted than when about to pronounce clearly the first letter of the word *wed* or the two last letters of the word *glue*. As little passage as possible is to be given to the air, and the breath is to vibrate on the lips alone, quite free from and beyond the teeth. This may be practised with the words *bu*, drunk; *du*, of the; *bru*, daughter-in-law; *cru*, raw, rough; *dru*, thick; *glu*, glue.

The thinnest and lightest of all the French vowels is *i*. This sound, which somewhat resembles *ee* in *feet* or *ea* in *eat*, *tea*, is faithfully produced by nearly closing the teeth, having the upper row slightly further forward than the lower, and while the tongue is just touching the under teeth, causing the sound, as it passes through the cavity of the mouth, a little flattened, to strike against the upper teeth in its way out. Practice may be taken with the words *fi-ni* (fee-nee), finished; *ici* (ee-see), here; *pipe* (peep), pipe; *mi-di* (mee-dee), noon; *di-vi-si-bi-li-té*, *ci-vi-li-té*.

E is the most difficult of the French vowels to manage well. There is little or no trouble indeed with *ê* circumflex, *è* grave, and *é* acute. These are pronounced (1) like the *a* in *fate;* (2) like *ay* or *ey* in *pray*, *prey;* (3) like *e* in *trespass*. To produce the sound, the teeth are nearly closed, the under lip is slightly depressed, the sound strikes on the roof of the mouth and flows freely forth, and is then modified by the amount of openness given to the teeth. An easy word for practice is *ré-gé-né-ré* (rĕ-jĕ-nĕ-ray); so is *lé-gè-re-te* (lĕ-jay-r-tay).

The other sound of *e* is weak, short, and slight, somewhat like the *u* in *hurt* or *e* in *her* rapidly spoken. It is almost the briefest expiration of air that can be made, especially in the monosyllables *de*, *le*, *ne*, *se*, *je*, *ce*, *te*, *que*, in which it is scarcely appreciably audible. It is a sound so continually recurring that the greatest possible care is taken to elide it whenever it can be done without injury to sense and with benefit to the harmony of a phrase; and, when it is impossible to elide it, it is omitted, or as faintly as may be glided over. Though rules cannot supply the want of a well-attuned ear and dexterity of tongue, yet a few of the more special peculiarities of the usage in regard to this *e*-sound (or rather semi-shadow of a sound) may help to bring some of them under the notice of the mind, and may thus be impressed on the memory for guidance in practice. *E* mute in the body of a word is scarcely perceptible as a sound, like the *e* in *flattery*, when that word is pronounced as if consisting of two syllables; e.g. *amical(e)ment*, amicably, is sounded as four syllables—a-mi-cal-ment. At the end of a word of more than one syllable it has no perceptible sound. But when several monosyllables ending in *e* mute come together, the second, if there are only two, is slightly heard, and if three, the third, and so on, though a great deal is left to the taste and sense of harmony of the speaker.

There are plainly enough recognizable in French three distinct modifications of the sound *o*, viz., (1) long, as in *pôle*, *môle*, *rôle*, *hôte*, like the English *o* in *stone* or *doleful;* (2) intermediate, as in *bo(t)*, *flo(t)*, *mo(t)*, *so(t)*, like *ow* in *grow;* and (3) short, as in *co-lo-nie*, *for-me*, *bon-ne*, as in English *rot*, *rob*. The combinations *au*, *aux;* *eau* and *eaux*, have the same sounds as *o;* e.g. *au*, *aux*, *che-vaux*, *au-tre*, *aus-si*, *nau-fra-ge*, *eau*, *ca-deau*, *beau-té*, &c.

In the pronunciation of the vowel *a* there are three perceptible distinctions in the extent to which the mouth must be opened to produce it, though no change in the relative position of the organs requires to be made. These are (1) long, as in *âme*, *mâle*, *âge*, *base*, *phrase*, like *a* in English *calm* or *art;* (2) mediate, as in *gare*, *rare*, *mare*, *barre*, as in English *ardent* or *pardon;* (3) short (which prevails in French), as in *fa-tal*, *ca-ta-ract*, *sa-la-de*, *ca-ma-ra-de*, as in English *cattle*, *salary*, &c. *A* is generally long when (1) it has a circumflex

placed over it; (2) it precedes the syllables *ble* and *tion;* (3) it stands before the liquid *ill;* (4) it has *bre, brer; dre, drer; vre, vrer*, after it; and (5) in the terminations *as* and *ase*, as in *a-mas*, heap, *re-pas*, repast, *li-las*, lilac, *hé-las!* alas! *ca-se*, hut, *va-se*, shine, &c.

Pedants in French instruction supply the learner with fifty-seven delicate *nuances* or slight varieties of intonation made in these two vowel sounds *a* and *o;* but the greater part of these will be found to be really the effect of the influence of the consonants with which they are joined.

The next series of sounds requiring the student's attention is that represented by the letters *ou, on, an, un*, and *in. Ou* issues from the lowest portion of the larynx, and is the fullest and most rotund of sounds, like *ough* in *through*, as *cou-cou*, cuckoo, *jou-jou*, plaything, *bouche*, mouth, *douche*, bath, *nous*, we, *tous*, all, *Tou-louse*. *On* is formed by rounding the mouth as in ô, only having the lips thrust out rather further, then allowing the formed sound to escape by the mouth and the nose. This sound will be readily intercepted and observed in *ong* of the word *songlike*, except that the French *n* is less nasal than the English *ng*. Examples—*Bon-bon, ca-non, don-jon, mou-ton, pon-ton*, &c. *An* is pronounced similarly but less fully, as in *fang, flank*. Examples—*Ma-man, en-fan-t, can-can*, tittle-tattle. *Un* is a thinner, slighter, but still resonant sound of *u*, with the nasal interception, as *un* in *uncle*. Examples—*Brun*, brown, *com-mun, par-fum*, perfume, *au-cun*, none. *En* gives the sound a more forward vibration towards the upper gum, and closes the nasal orifice more thoroughly, as in *length*. Examples—*En-nui, a-ven-tu-re, en-n(e)-mi, hen-nir*, to neigh, *a-men-de*, fine (inflicted), *ar-gen-t*, money. (This sound is scarcely perceptibly different from *an*). *In* places the mouth, throat, and lips as for the pronunciation of *ah*, lowers the under jaw, and makes the sound vibrate towards the palate, somewhat as *y-ing* in *flying*, but again less markedly nasal. Examples—*Ma-tin*, morning, *ma-rin*, sailor, *jar-din*, garden, *la-pin*, rabbit, *ins-tin-ct, ma-lin*, malicious.

READ ALOUD.

Pa-pa, ca-ge, pa-ge, sa-ge, da-me, la-me, ra-me, da-te, ra-de.
Pè-re, mè-re, dé-ja, bé-bé, fê-lé, zè-le, fu-té, pe-lé.
Co-de, mo-de, so-lo, zé-ro, no-te, co-ke, lo-ge, jo-li, ro-be.
Bi-ble, mi-di, vi-de, ma-ri, pa-ri, pi-pe, pi-le, po-li.
Lu-ne, tu-be, cu-ve, ju-ge, du-ne, ju-pe, pul-pe, ju-ju-be.
Ma-la-de, pa-na-de, sa-la-de, ca-po-te, pe-lo-te, pi-lo-te.
Na-tu-re, u-ti-le, fu-ti-le, do-ci-le, mo-dè-le, vi-pè-re.
Vic-tor a per-du le ca-nif de pa-pa.

TRANSLATION.

Papa, cage, page, wise, lady, blade, oar, date, roadstead.
Father, mother, already, doll, wild, zeal, shrewd, bald.
Code, mode, solo, zero, note, coke, lodge, pretty, dress.
Bible, noon, empty, husband, wager, pipe, pile, bright.
Moon, tube, vat, judge, sand-hill, skirt, pulp, jujube.
Sick, bread-pudding, salad, cloak, dumpling, steersman.
Nature, useful, useless, mild, model, viper.
Victor has lost the knife of papa (papa's knife).

The following exercises on the nasal sounds should be carefully read and re-read, referring constantly to the directions given above.

***On*, *eon*, and *om*, as *ongh* or *ong* in *songlike*.**

Don-don, bon-don, par-don, car-don, ar-çon, gar-çon.
Plump, stopper, pardon, thistle, vine-twig, boy.
Bour-geon, dra-geon, hau-ber-geon, pi-geon, plongeon.
Bud, shoot (sucker), cuirass, pigeon, diver.
Om-bre, om-bel-le, om-bra-ge, nom, plom-be.
Shade, umbel, shadow, name, hailshot.

***An*, *am*, *aon*, and *em*, *en*, *ean*, like *angh* or *an* in *ankle*.**

Flan, plan, flam-be, jam-be, pa-on, am-bu-lan-ce.
Custard, level, fleur-de-lis, leg, peacock, ambulance.
Em-bar-ras, en-fant, na-geant, chan-geant.
Embarrassment, child, swimming, changing.

***In*, *im*, *aim*, *ain*, *ein*, like *aingh* or *y-ing* in *flying*.**

Fin, lim-be, tim-bre, faim, pain, plein, rien, chien.
End, limb, voice, hunger, bread, full, nothing, dog.

***Un*, *um*, and *eun*, like *ungh* or *un* in *uncle*.**

Alun, brun, cha-cun, em-prun-ter, par-fum, à jeun.
Alum, brown, everyone, to borrow, perfume, fasting.

A careful practice of the exercises in pronunciation given above, if due care is taken to catch and retain in the ear the precise sound, ought to enable the student to attain facility and accuracy of utterance. Labour spent, first in appreciating the key-sound, and next in uttering it slowly and carefully, until the precise tone has been gained, will not be lost.

Liaison (from *lier*, to unite).—A word ending with a consonant coming before another (to which it is grammatically related) beginning with a vowel or *h* mute, transfers the sound of its final consonant to the following word: *mon oncle*, mo-noncle; *sans ami*, san(gh)-zami.

When the word whose final sound is carried to another ends in *c, d, f, g, s, x*, the sound transferred is that of *k, t, v, k, z, z* respectively; *k, l, n, p, q, r, t, z*, when they precede a word beginning with a vowel, retain their sound unchanged; but as this plan is adopted to secure speed of speech and harmony of sound, whenever, in conversation, these purposes would not be served, and the phrases would be made harsh or unpleasant, the transference of these sounds is avoided, especially in the cases of *t, s, x*, and *z*. The *t* of the conjunction *et* is never sounded.

In public speaking or in reading poetry the final consonant of a word is always joined to the initial vowel of the following word, except only some words in which the final consonant remains mute, such as *b* in *plomb*, *g* in *poing*, *p* in *camp*, &c. The *n* or *m*, which serves to form a nasal sound, is joined to the following vowel only when there cannot be any pause between the two words, and then the nasal sound is not heard; thus, we must say *mon ami*, my friend; *un Européen*, an European; *son ambition*, his ambition; but we say always, without uniting the words, *passion | aveugle, ambition | insurmontable*.

In conversation or in familiar reading the union of the final consonant and the vowel of the next word takes place only when the words are by grammatical relation inseparably connected; such are, the adjectives preceding the nouns, the articles and substantives or adjectives, the pronouns and their substantives or verbs, the adverbs and the words which they modify, &c.

The grammatical relations in which the additive transference of sound requires to be made is that between (1) article and noun, (2) adjective and noun, (3) pronoun and verb, (4) verb and adverb, (5) a preposition and the word it governs, (6) compound words, (7) auxiliary and participle. Of course, when a word is followed by any punctuation mark, the final consonant is not carried over to the next word though it begins with a vowel. The conjunction *et* is never joined to the following word, nor is the plural of nouns in *es* carried over. When two nasal sounds come together (unless they are monosyllables) there is no transference of sound from former to latter. In fact, a fine ear and a sound judgment are the only trustworthy guides in regard to verbal liaison, for often an unintended sense may be given or avoided by the use or omission of it, *e.g. Vous ne ferez jamais un bon marin, Vous êtes trop homme de terre*, signifies, You will never make a good sailor, You are too much of a landsman; but if the liaison is used at *trop homme* it will take the form *Vous êtes trop pomme de terre*, You are too much of a potato. The following sentences illustrate the use of liaisons (or ties):—*C'est lourd à porter*, It is heavy to carry. *Il est arrivé à un rang(k) élevé*, He has reached a high position. *Cet hiver il était à Londres*, This winter he was in London.

NATURAL PHILOSOPHY.

INTRODUCTION.

The natural sciences present so extensive a field of inquiry that the limited faculties of a single individual are altogether inadequate for the full development of their rich resources; consequently a division of labour is indispensable for their successful study. The division which naturally suggests itself originates in the intercourse which is maintained, through the agency of the senses, between the intellectual principle within us and the material existences without—between the world of

mind and the world of matter; each of these departments has been further divided and subdivided as the principles have been more fully developed and applied.

The science of matter, or *natural philosophy*, as it is more commonly designated, considers the properties of material bodies, and their mutual action and dependence upon each other; and the end proposed by the cultivation of the science is, to enable man to comprehend more fully and satisfactorily than he could otherwise do, the mechanism of the universe, and to make nature and art subservient to the necessities and conveniences of life by skilfully connecting causes which will produce the most beneficial effects. This department is subdivided into two parts—viz. *chemistry* and *physics*, or natural philosophy, used in a more limited sense. The former, by analysis or decomposition, ascertains what elementary substances constitute compound bodies; by composition, or synthesis, what bodies will result from the combination of particular elementary substances; it investigates and illustrates the laws by which such combinations take place, and states the results. The latter, with which we have more immediately to do at present, neglects entirely the composition and decomposition of bodies; it enters not into those secret recesses, where, by interesting combinations of two or more of about sixty different substances, nature exhibits, in all their charming variety and beauty, the interesting objects around us; it has to do with laws which are, in most cases, more palpable to the senses, more general in their operation, and fewer in number. While the principles of physics provide subjects of the highest interest to the philosopher, to the practical man, and society in general, they have a more interesting and imposing aspect, as they are perceived to bear directly or indirectly upon the business of human life. Interesting as natural phenomena are, in so far as they exemplify general laws, they become still more so to mankind in general when viewed in their practical application to the modern arts, more particularly such of them as have a direct influence upon our comforts and enjoyments. From mechanical science we have received those machines through whose agency we are enabled to convert wool, cotton, and flax into warm and comfortable clothing; from chemistry, those substances by which we can dye and imprint the manufactured article with varied colours and patterns.

Mechanical science has converted the distaff into the spinning-jenny, a machine of such exquisitely delicate construction that it can convert 1 lb. of cotton into a thread 132 miles in length. From thermics and mechanics combined we have received the steam-engine, which is now employed in almost every department of human industry. Electrical science has given us, with the telegraph and submarine cable, the power of conveying intelligence from one place to another, almost annihilating time and distance. From electricity and acoustics combined we have received the telephone and phonograph, enabling the human voice in articulate language to be transmitted over long distances, and speech to be written down and reproduced at will. From electricity and mechanics combined we have derived the electric light. From the sciences of optics and of chemistry we have received the spectroscope and the knowledge of spectrum analysis. From mechanics and chemistry we have derived the gas engine and hot-air motor. The illustrations of the advantages derived from mechanical knowledge and the applied sciences, indeed, are so numerous that it is unnecessary to enumerate them. They will be more fully considered in connection with the principles on which they depend.

CHAPTER I.

GENERAL PROPERTIES OF MATTER.

The objects which surround us on all sides, and which we can see, handle, or weigh, constitute what is called matter. Most solid substances, as we know, can, by the application of mechanical means, be reduced to extremely fine powders; but when this mechanical division has reached its utmost limits, the application of the microscope still reveals the individual particles composing the powder. In nature all bodies are supposed to be built up of very minute particles, called *molecules*. These in turn are made up of still smaller particles, termed *atoms*, which are far too minute to be seen with the most powerful microscope, and are supposed to be separated from one another by spaces many times as large as the atoms themselves. Though bodies may be resolved into molecules, and molecules into atoms, it is not possible to divide the atoms; they are considered as indivisible. Sir W. Thomson has deduced, from calculations based upon various physical phenomena, that the average distance between atoms in ordinary solids and liquids is somewhere between the one hundred-millionth and the two thousand-millionth of a centimetre, and by the following illustration attempts to convey some idea of the size of the molecules—"Imagine a drop of rain, or a glass sphere the size of a pea, magnified to the size of the earth, the molecules in it being increased in the same proportion, the structure of the mass would then be coarser than a heap of fine shot, but probably not so coarse as a heap of cricket balls." The fragrance of the rose is but the giving off from the flower ponderable matter in the form of molecules, each of which again is composed of atoms.

It has been supposed by some that such molecules are disseminated in straight lines through space—the hypothesis of *translation* in contradistinction to the hypothesis of revolution. It may be remarked how quickly an odorous perfume fills a room, and this fact harmonizes with the conception of the direct projection of the molecules. If this theory of the rectilinear motion be true, it can be proved that the molecules must move at the rate of several hundred feet a second; and a reason why the odours do not spread much more rapidly than they are observed to do, is that the odorous particles have to make their way through a crowd of air-atoms, with which they come into incessant collision. The distance through which a molecule can travel in common air without striking against an atom of air is infinitesimal, and hence the propagation of the odorous particles through air is enormously retarded by the air itself.

As all bodies are built up of molecules, the substance of a body depends upon the internal structure and arrangement of its molecules, and all the molecules of the same substance are supposed to be exactly alike. A body may be divided or subdivided into any number of parts, but the substance of each part will remain the same so long as the molecules are unchanged; but if the molecules are divided or their structure is altered by changing the kind, number, or grouping of their atoms, the substance of the body is changed. This is well illustrated by an ordinary railway carriage axle. The substance of the body of iron, by continual concussion and motion, becomes changed. Instead of remaining tough and fibrous, as when the molecules were in their original state, it becomes crystalline and brittle, the molecules forming the mass having changed in their position and grouping.

All space is supposed to be filled by a highly-rarefied and elastic fluid, called *ether*; it fills alike the voids of space among the fixed stars, through which the earth and planets revolve round the sun, and those among molecules and atoms. It is considered to be imponderable (without weight), and offers no resistance to bodies, molecules, or atoms moving about in it. This subtle substance makes the universe a whole, and renders possible the intercommunication of light and energy between star and star. It is considered that the ether is capable of taking up the motions, varying in character and velocity, of the ultimate particles of matter; thus a motion of one kind communicated to the ether gives rise to the phenomena of heat; a similar motion, but of greater velocity, is the cause of light, and possibly electricity may also be due to some form of motion imparted to the ether.

As all matter contains spaces which are not occupied with material particles, and no substance is known whose parts by pressure are absolutely incapable of yielding one among another, particles which admit of such nearer approach to each other cannot, of course, be in close contact, and therefore a mass or assemblage of such particles must be *porous*. When the pores are too minute to be seen under the powers of the microscope, they are called physical pores; in those substances where the pores are large enough to be seen, they are called sensible pores. Though apparently of great density the porosity of iron is simply illustrated. At the time of the construction of the earlier submarine telegraph cables, the

integrity of the insulated core was usually tested by its being subjected to immense hydraulic pressure. For this purpose large iron cylinders were constructed, the sides of which were from 10 to 12 inches in thickness, within which the core was coiled, and the covers afterwards closed down by powerful lever clamps and screw bolts ; water was then forced in under enormous pressure ; but notwithstanding the great thickness of the iron cylinders the water was forced through the pores of the substance of the iron, and the external surfaces of the cylinders literally freely perspired with moisture. This illustration likewise exemplifies the stupendous pressure necessary to compress the molecules constituting water. The atoms of matter are giants in disguise as regards the might of that energy necessary to cause either their separation or condensation.

In nature the three orders of material units are atoms, molecules, and bodies. Every particle of matter in the universe is in incessant motion. The atoms are continuously moving about in the molecules, the molecules in bodies, and bodies in space. The motion of the atoms within the molecules is called atomic motion ; the motion of the molecules in bodies, molecular motion ; and the motion of bodies in space, molar motion. The term molecular, however, is frequently applied to the motion of both atoms and molecules.

This motion is exemplified on a stupendous scale in stellar space. The sidereal universe is composed of stars, each of which, like our own sun, is probably the centre of a solar system composed of sun and planets. The planets and their satellites which revolve around the great central luminary, the sun, composing the solar system, correspond to the atoms which compose the molecules ; the sun itself and the stars, mere atoms of luminous dust in that vast agglomeration of stars, the Milky Way, to the molecules; and the Milky Way, itself an agglomeration of world-systems, to the bodies. Here we have, in the revolution of the planets round the sun, the motion of the atoms ; in the movement of the solar system through space, which we know travels in the direction of the constellation Hercules with a velocity of some 412,000 miles per day, the motion of the molecules ; and in the Milky Way, an archipelago in motion that travels in infinite space, the motion of the bodies.

There are three great forces of nature which correspond to the three orders of material units ; these are *affinity*, *cohesion*, and *gravity*.

Affinity is that power or force which binds together the atoms into molecules, or which resists their separation when once combined. Such forces as gravitation, heat, light, electricity, and magnetism act through distances more or less great; the force of affinity, on the other hand, differs from the attraction of gravitation in not acting on masses—it acts only through infinitesimal portions of space inappreciable by us. This atomic force, which binds atoms together to form masses, is enormous. Closely locked together as they are, the atoms of bodies, though they cannot be supposed to be in actual contact, exert immense attractions; it would require an almost incredible amount of mechanical force to widen the distance intervening between the atoms of any solid or liquid so as to increase its volume in any sensible degree. It would also require a force of great magnitude to squeeze the particles of a solid or liquid together so as to make the body less in size. Hence the magnitude of the forces engaged in producing atomic motion, as measured by any ordinary mechanical standard, is surprising: 1 lb. of iron on being heated from 0° to 100° C. expands about $\frac{1}{800}$ of its volume, an amount which would be insensible to the most accurate eye ; still to give its atoms the motion necessary to shift them through the small space indicated, an amount of force is requisite which would raise about 8 tons a foot high. The force of gravity almost disappears in comparison with the molecular forces, which are the strongest of the forces in nature.

Cohesion is the force that binds together the molecules of matter into bodies. A solid body built up of molecules retains its form and solidity by virtue of cohesion, which causes the molecules to attract each other and cling together, forming collective masses ; it is therefore a molecular force. Molecular cohesion can be partly overcome by the application of more or less force to separate the parts. Cohesion is a weaker force than affinity, but is capable of acting through greater, though still insensible, distances. The distinction between cohesion and gravitation consists in this: cohesion binds particles together, and is perceptibly exerted only at extremely small distances ; gravity operates between masses and at all distances.

The laws of gravitation express not only the fact of the mutual attraction of all matter, but also that this attraction decreases as the distance increases. This attraction of bodies for one another, when manifested over sensible distances, is called gravitation or *gravity*, and the more closely the bodies approach, the more intensely is their attractive influence upon each other exerted. The gravitation or attraction of one body upon another does not depend on the mass of the body which is attracted, but remains the same whatever be the mass of the body so attracted, if the distances are the same. For instance, the planet Jupiter attracts the sun and the earth also ; but although the sun's mass is 300,000 times as great as the earth's, yet the attraction of Jupiter on the sun is exactly equal to his attraction on the earth, when both are equally distant from Jupiter. The attraction of gravitation is always proportional to the mass of the body which attracts, if the distances of different attracting bodies be the same. Thus, if the sun and Jupiter are at equal distances from the planet Saturn, the mass of the sun is about 1000 times as great as that of Jupiter ; then, whatever be the space through which Jupiter draws Saturn in one second of time, the sun draws Saturn in the same time through 1000 times that space. If the same attracting body act upon several bodies at different distances, the attractions are inversely proportional to the square of the distance from the attracting body. Thus, assuming the planet Saturn to be ten times as distant from the sun as the earth is, the sun's attraction upon Saturn is only one-hundredth part of his attraction on the earth. The term gravitation is sometimes used to signify the power by which bodies descend to the earth, evidenced in their *weight*. Of the three great forces of nature, gravity, while it is capable of acting through all known distances, is the weakest.

The tendency of a body to return to or spring back to its original form, when it has been disturbed by the pressure of another extraneous to it, is termed *elasticity*. It is the reacting force by which it sustains or tends to remove that pressure. Any distortion, however produced, is called a strain, and the force which produces it is termed a stress. All bodies are more or less elastic, but whenever the strain proceeds beyond a certain point the elasticity of the body breaks down. This point is termed the breaking strain of the body. The elasticity of stone may be observed by the rebound of a marble on striking a stone floor ; in the same way the rebound of the bullet on striking an iron target illustrates the elasticity of iron.

CHAPTER II.

UNITS OF MEASUREMENT—ACTION OF FORCES ON MATTER.

In mechanics the three fundamental units, from which all the other mechanical and physical units are derived, are—the *unit of time*, the *unit of length*, and the *unit of mass*. In the English system these units are severally the second, the foot, and the pound (avoirdupois) ; in the French system they are the second, the centimètre, and the gramme.

The precise length of the unit of the second is determined by observation of the instant that the transit of the sun's centre takes place over the meridian of the spot from which the observation is made; and the interval between two successive transits constitutes a solar day. As the length of the solar day varies slightly from day to day, an average is taken, which constitutes a mean solar day. This has been divided into twenty-four equal parts or hours, each of which again is subdivided into sixty equal parts, called minutes, and the minute again into sixty equal parts or seconds; the second is therefore the 86,400th part of a mean solar day.

The English standard *unit of length* is the yard, which is subdivided into three equal parts, called feet. The foot is subdivided into twelve equal parts, called inches: the inch

may again be subdivided into decimal parts of an inch. The yard measure is simply the length recorded upon a standard brass rod retained in the Tower of London, engraved "Standard Yard, 1760," and from which all accurate measures are taken. In this brass rod two pins of gold are inserted, their surfaces being level with the rod; and a small dot is made in the middle of each—the distance between the centres of these two dots, taken when the temperature is at 15·5° C., represents the imperial standard yard. According to an Act of Parliament (5 Geo. IV. c. 74), a standard yard is $\frac{36}{39 \cdot 1393}$ of the length of a pendulum which beats mean seconds of time in London, at the sea-level, in a vacuum; and by this means the standard yard measures could be restored should they ever be destroyed.

The French standard unit of length is the mètre. This linear measure takes for its basis the distance from the equator to the pole, which distance is divided into 10,000,000 parts; one of such parts is a mètre, the length having been estimated from actual measurements taken between Dunkirk and Barcelona. The mètre is 39·3707 inches as compared with 39·1393 inches, the length of the seconds pendulum. The mètre is about 3¼ feet; it is divided into 10, 100, and 1000 equal parts, called respectively décimètres (3·937 inches), centimètres (0·3937 of an inch), and millimètres (0·0394 of an inch). The multiples of the mètre again are the decamètre (10 mètres), hectomètre (100 mètres), and kilomètre (1000 mètres.) A kilomètre is about five-eighths of a mile, and 8 kilomètres equal 5 miles. In the French metric system of units, the prefixes *déci*, *centi*, and *milli*, denoting divisions of the metric standard, are taken from the Latin, and indicate tenths, hundredths, and thousandths of the unit; while the prefixes *deca*, *hecto*, and *kilo*, denoting multiples of the metric unit, are taken from the Greek, indicating tens, hundreds, and thousands of the unit.

The *units of surface* are squares, one side of which is the unit of length. The English units of surface are the square yard (9 square feet, or 0·836 of a square mètre). The square foot (144 square inches, or 9·29 square décimètres), and the square inch (6·451 square centimètres). The French units of surface are the square mètre, the square décimètre, and the square centimètre.

The *units of volume* are cubes, one of whose edges is the unit of length. The English units of volume are the cubic yard (0·7645 of a cubic mètre), the cubic foot (28·3153 cubic décimètres), and the cubic inch (16·38617 cubic centimètres). The French units of volume are the cubic mètre, the cubic décimètre, and the cubic centimètre. The French unit of capacity is the cubic décimètre, and is called the *litre;* it is 1·76 of the pint and 0·22 of the gallon.

The *mass* of a body is the quantity of matter which it contains, and it is always proportional to its weight or gravity whatever its figure may be. The English *unit of mass* is the mass of a certain portion of metal, called the *pound avoirdupois;* it is divided into 7000 equal parts, called *grains.* The French unit of mass is the mass of a cubic centimètre of water at 4° Centigrade; it is called a *gramme*, and represents 15·4323 grains, or about 15½ grains. A kilogramme is equal to about 2¼ lbs., or 2·2046 lbs. avoirdupois exactly.

The *density* of a body is the proportional weight or the quantity of matter in a unit of its volume. Thus, in two cubes of equal size or magnitude, if one weighs only 1 lb. and the other 2 lbs., then the density of the latter is double that of the former. Water at a temperature of 4° C. is usually taken as the unit of density. As the density of a body is the mass of the unit of volume, if m denotes the mass, v the volume, and d the density of the body, then $m = vd$. If an equal volume of any second body be taken whose mass is m' and density d', then $m' = v\,d'$, or $d : d' :: m : m'$; therefore the density of bodies is in the same ratio as masses of equal volumes of those bodies.

The rate of motion by which a body passes over a certain space in a certain time is termed its *velocity*. Thus, if a body in motion pass over 60 feet in 5 seconds of time, it is said to move with the velocity of 12 feet per second. It does not, however, follow that its motion will be exactly uniform throughout the entire distance during the 5 seconds of time, for its rate may change.

Any power, push, or pull, of whatever origin, exerted upon any portion of matter to move it or to stop it, is called a *force.* If the force act constantly or incessantly it is a permanent force; but if it act instantaneously or for an imperceptibly small time, it is called an *impulse* or a *percussion.* In regard to matter these forces always act between two different portions of matter. The action of a force or *stress* between two portions of matter takes different names according to the mode in which it acts; it may be termed attraction, repulsion, tension, pressure, torsion, &c. When attention is confined to one of the portions of matter only one aspect of the stress is observed, the effect produced on the portion of matter under observation; this is termed, with reference to its effect, an *external force*, and with reference to its cause, the *action* of the other portion of matter. The opposite aspect of the stress is called the *re-action* on the other portion of matter.

CHAPTER III.

FIRST LAW OF MOTION.

Before proceeding to consider the Newtonian laws of motion and universal gravitation, it may be interesting to trace back and ascertain the position in which the science of observation stood prior to the investigations of Newton. At a very early period it had been laid down as a principle by Aristotle, that the motions of the celestial bodies were regulated by laws proper to themselves, and having no relation to those which prevailed on the earth. This view established a broad and impassable line of separation between celestial and terrestrial mechanics, and greatly impeded the progress of experimental research. Science was therefore reduced to a mere record of facts, in which theory had no part, except to attempt to reconcile various observed irregularities of the celestial motions with the assumed law of uniform circular motion of the celestial mechanism. Copernicus afterwards adopted a more rational system, which regarded the sun as the centre of our system, and gave to the motion of the heavenly bodies a simplicity which at once commanded attention. The variations in the apparent size of the sun and moon were, however, too small to be measured without the aid of a telescope, and the bodies of the planets could not be distinguished as having a distinct mass by the naked eye alone. The Copernican system, however, once admitted, this difficulty was overcome, and it became a mere series of geometrical problems and calculation to determine from observation of the places of a planet its real orbit round the sun and other circumstances of its revolution. Kepler's investigations established the orbit of Mars, which he ascertained to be an ellipse having the sun in one of its foci; and the same law being extended by inductive reasoning to the other planets was found to be verified. The laws thus established by Kepler constitute the most important and beautiful system of geometrical relations ever discovered by a mere process of inductive reasoning. They form a compendium of the motions of all the planets, by which their places can be assigned in their orbits at any instant of time, past or to come, and are dependent upon purely geometrical conditions numerically resolved. The invention of the telescope and its application by Galileo to celestial objects resulted in the discovery of Jupiter's disc and satellites, a system in miniature of the greater one in revolution round the sun, of which it formed a portion; and the laws which Kelper had enunciated regarding the time of revolution of the planets and their distances from the sun were found to coincide with those of the revolution of the satellites round the central mass of Jupiter. The investigations conducted by Galileo into the laws of falling bodies and the motions of projectiles laid the foundation of a true system of dynamics, by which motions could be determined from a knowledge of the forces producing them, and forces from the motions they produce. Until Newton applied his mathematical knowledge to grapple with the subject everything regarding the laws of motion was relegated to theory, and little advance had been made beyond preparing a state of knowledge in which powers like his could be effectually applied. Ascending by a series of inductive arguments to the highest laws of dynamical science Newton succeeded in applying them to the complete explanation of all

the great phenomena relating to matter, and pointed out that all the celestial motions known in his time and established by Kepler and Galileo were consequent upon a simple law, that every particle of matter attracts every other particle of matter in the universe with a force proportional to the product of their masses directly and to the square of their mutual distance inversely, and is itself attracted with an equal force.

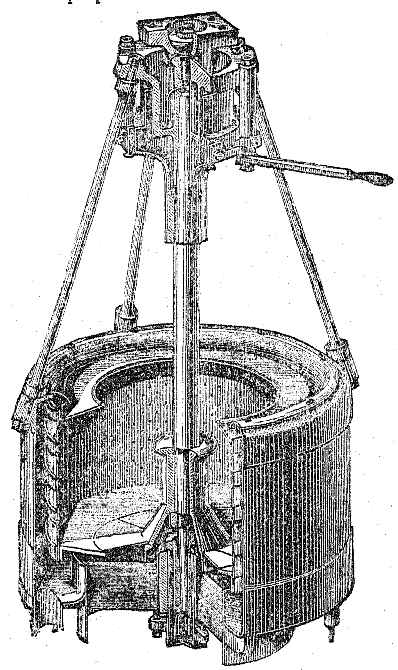
Proceeding to applications of this law to problems of greater intricacy, Newton demonstrated the inequality of the moon's motion round the earth as resulting from the attraction of the sun's mass, and how tides arise from the unequal attractions of the sun and the moon on the earth and the ocean which surrounds it. The more recent discoveries of five primary planets, mostly deviating from the general analogy of the others, and the intricate questions arising from the highly-elliptical orbits of most of the system of comets round the sun, only tend to demonstrate the law of the absolute invariability of the mean distance of each planet from the sun, and that though the mutual actions of the planets, upon each other, can produce in the course of indefinite ages certain changes, they are *periodical*, increasing to a certain extent and then diminishing, so that the great system of the universe can never be destroyed or subverted by the mutual action of its parts, but is kept constantly in motion, oscillating round a centre, from which it can never deviate.

The researches of Laplace and Lagrange have further demonstrated the absolute invariability of the mean distance of each planet from the sun; and relying upon these grand discoveries the physicist can look forward from the present point of time many thousands of years into futurity, and predict by calculation the state of our system without fear of material error, but such as may arise from causes whose existence at present we have no reason to suppose.

The First Law of Motion is that *every body naturally tends to continue in its present state, whether it be at rest or moving uniformly in a right line.* In the universe, so far as is known, no portion of matter is absolutely at rest. Bodies are usually said to be at rest when they are not changing their positions with respect to other bodies around them. Thus a person seated in a railway carriage, travelling at express speed, may be said to be at rest, although in reality he is moving forward at the same velocity as the carriage. In the same way bodies are said to be at rest on the surface of the earth, though all the time they participate in the motion of the revolution of the earth on its axis. When a body is said to be put in motion it is meant that its motion is changed either in rate or direction. A moving body, unless acted upon by external forces, would always go on in a straight line and at a uniform speed. At the surface of the earth, however, all moving bodies show a decided tendency to stop; they are acted upon by some external force acting as a resistance.

The resistances chiefly encountered by moving bodies are the *resistance of the atmosphere* and *friction.* In proportion as these resistances are diminished the longer is the time a body will continue to move. A railway train set in motion will continue running much longer on the smooth iron rails than if the train were in motion over a rough road. As, therefore, the time that a body will continue in motion increases in proportion as the resistance is diminished, it may be inferred that were the resistance entirely removed the body would continue in motion for ever. This property of matter, by which it does not change its state of either rest or motion, unless acted upon by some external force, is called *inertia.* The inertia of a body is directly proportional to its mass. It takes time for a force to overcome the inertia of matter; hence when a body receives a sudden blow the part of the body immediately receiving the blow yields before there is time to overcome the inertia of the surrounding parts. A familiar example of inertia is, that a soft body fired with a sufficient velocity will hit as hard as lead, and a tallow candle may thus be fired through a deal board.

The state of matter left to itself is either that of rest or uniform motion in a straight line, and every other species of motion, of whatever sort, is an effect of force from without. The so-called *centrifugal force* is simply the tendency of the parts of a rotating body to keep moving in straight lines; this tendency increases with the speed of rotation, and sometimes to such a degree as to overcome the cohesion of the body, which will then fly to pieces. The serious accidents so frequently caused by the bursting asunder of large grindstones and heavy flywheels in rapid rotation are due to this force. If a cord be fastened to an immovable obstacle, say a post, and pulled with force of, say, 1 cwt., the action or resistance of the post is the equivalent of the force, because were the post removed the cord would need to be pulled by a tension equivalent to 1 cwt. to counteract the moving tendency of the first tension applied; therefore the resistance of an immovable object has to be regarded in precisely the same manner as a physical attraction, a muscular effort, or any other mode of accelerating or retarding velocity. Again, if a bullet be caused to revolve with a given velocity round a fixed point by means of a string, it will continue to revolve with the same velocity, friction and the resistance of the air not being supposed to exist, and the string will be stretched by a pressure depending upon the mass of the bullet and its velocity. The reason of the permanence of the velocity is contained in a proposition demonstrated in mechanics, namely, that forces applied to a material point in a direction perpendicular to that of its motion cannot



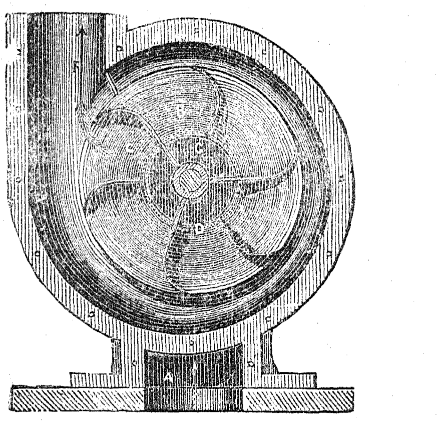
Centrifugal Wringing Machine.

change its velocity, but only its direction. In the present case the bullet must describe a circle; and the direction of the string, in which the retaining pressure acts, is always perpendicular to the tangent of the circle, being always a radius. This pressure on the string is caused by an effort to escape on the part of the bullet, arising from its tendency to continue its motion in the direction of the tangent. This is the *centrifugal force,* and does not arise from any tendency which the bullet has to fly from the centre, but from the circumstance that there is in the motion above described a constrained approach to the centre, such as would not exist in the motion of the bullet uninfluenced from without. The faster the body moves, the greater the pull needed to keep the body in its circular path; the greater the pull upon the body towards the centre, the greater the pull of the body away from the centre. The pull exerted on the body *towards* the centre is called the *centripetal force.*

The pull of a revolving body away from the centre is illustrated by the flattening of the sphere of the earth at the poles while in a fluid state, the pull being greatest at the equator, the central point of the circumference, because this part was rotating at a greater velocity. The action of the two balls of an ordinary steam-engine governor, which fly

open at a greater or less angle as the governor revolves with a greater or less speed, is another example of centrifugal force; another illustration is the every-day practice when drying an ordinary mop saturated with water, to set the mop in rapid rotation by the action of the palms of the hands upon the handle: the higher the speed of revolution the mop attains, the more energetic is the dispersion of the moisture contained in it, the particles of water flying off at a tangent with considerable force. The centrifugal wringing machine (illustrated on preceding page) so extensively used for drying purposes in laundries, paper mills, and sugar refineries, is a mechanical application of the principle on an extended scale. The direction taken by the particles of mud as they fly from the revolving wheel of a carriage is a further illustration of the centrifugal force. The tendency of the particles of matter to keep moving in the same plane explains why a bicycle is not easily overturned so long as its large wheel is in rapid rotation; it also explains the reason a top will remain upright so long as it continues to spin rapidly, though it topples over at once as soon as it comes to rest; the ordinary fan, as well as the centrifugal blower (shown in cut), where the air, being driven off by the fans B, D, and escaping at F, creates a partial vacuum at C, and causes a fresh supply to enter at A, are illustrations familiar to all.

External forces tend to put bodies in motion or to change their velocities, for if an elastic cord be fastened at one end to a body which is not acted upon by any other force than the tension of the cord, and the cord is stretched at the same



Centrifugal Blower.

time so as to exert a uniform pull on the body, the latter will move in the direction of the pull, and will move faster and faster the longer the pull continues, gaining the same amount of velocity each second. If it move at the rate of 3 feet a second at the end of the first second, it will be moving at the rate of 6 feet a second at the end of the second second, and at the rate of 9 feet a second at the end of the third second, and so on. Forces may be measured either by the pressure which they would produce, or by the rate at which they would increase the velocity of a mass of matter. In the former case the unit of force is the force of gravitation on a unit of mass. In the English system it is the force of gravity on the mass of a pound or a grain, and is called a pound or a grain. In the French system it is the force of gravity on a mass of a gramme, and is called a gramme.

These units are called *gravitation* units, and as they change with the intensity of gravity at different places on the surface of the globe, and at different elevations above the surface, they are variable. In the latter case the unit of force is the force that will impart to a unit of mass a unit of velocity in a unit of time. In the English system it is the force that will impart to a mass of a pound a velocity of a foot in a second, and is called a *poundal*. At Greenwich it takes 32·2 poundals of force to sustain a pound. A system of absolute measurement has been recently adopted by the British Association, the units of which are all based upon the centimètre, gramme, and second, as the three fundamental units of length, mass, and time. This system of measurement is called the centimètre-gramme-second system, or shortly the C.G.S. system. Its units are called the centimètre-gramme-second units, or more briefly the C.G.S. units. In this system the unit of force is the force that will impart to a mass of a gramme a velocity of one centimètre a second; it is called a *dyne*. It takes 445,000 dynes of force to sustain a pound at Greenwich. As these units are independent of gravity and are invariable, they are called *absolute units*.

The *momentum* of a body is measured by the mass and the velocity of the body, and is directly proportional to the two. The velocity remaining the same, the momentum or quantity of motion increases with the mass moved; and the mass remaining the same, the momentum increases proportionally to the velocity communicated. If two bodies have equal velocities, but one has nine times the mass of the other, it is said to have nine times the motion; or if the two have equal masses, and one has nine times the velocity of the other, it is said to have nine times the motion of the other. A diminution of the mass may be compensated by a proportionate increase of the velocity; that is, M being the number of units of mass and V of velocity, as long as the product of M and V remain the same, the effect produced is the same. Thus 3×100 is equal to 1×300. The product of the mass of a body and its velocity is called the *momentum* of the body.

ARITHMETIC.—CHAPTER I.

ARITHMETICAL NOTATION AND NUMERATION.

ARITHMETIC, as the art of reckoning, is one of the most necessary and useful applications of knowledge to the common purposes of every-day life. In some form or other the idea of number must have been early attained and employed. The shepherd with his flock, the hunter following his precarious pursuit of game, the fisher by riverside or on sea, the warrior marshalling his men or estimating the enemy, must all have exercised the art of counting. Even in the earliest conditions of life the idea and the art of number must have been acquired. Change, motion, and succcession are all around man, and meet his eye everywhere. Things in almost infinite variety attract his notice; and human experience and necessity must at an early date have given definite shape to man's first crude conceptions of numbers, and the peculiarities of their changes. Man did not, probably, all at once pass from thinking of things numbered or able to be numbered, to forming signs of numbers as applicable to things. But he could not long continue to employ names or signs of numbers without observing that he was able to use these terms or symbols apart from the things themselves. And so by degrees the most practical of the arts would rise into form in the mind, and be exercised in the business of life, long before it became a science or was thought of as a means of mental training. Similar is the distinction still between arithmetic as a practical and a disciplinary study. In the shop, the warehouse, and the counting-room; in all the commercial dealings of men; in all possible conditions of existence nowadays facility and accuracy in the use of figures is required. In every exercise and occupation its utility is felt, and calculation gains attention and claims importance. We have the good fortune in our day to find ourselves possessed of a simple and ready method of representing numbers, and have had the processes of employing them so thoroughly tested that we forget—if we ever knew—that things were not always so. Long long ages passed, and many illustrious men's minds have been engaged in working out for us this easy practical art, and in developing for us the principles of this most effective scientific discipline.

The earliest known use of the Arabic numerals occurs in a grant of land inscribed on copper, found among the ruins of Monghyr, on the right bank of the Ganges. It is dated 23 B.C. The knowledge of this system passed from Hindostan to Arabia, and was freely used by the Saracens. In the tenth century it was brought by them into Spain. Among the Florentines and other mercantile communities of Italy the new notation was welcomed and employed. Italian manuscripts of the early part of the thirteenth century show that the Arabian numerals were in pretty common use. It was

somewhat later before they were introduced into this country. In Chaucer's "Boke of the Duchesse" (1370) it is said—

> "For by *the figures newe* all kenne (= can)
> Yf they be crafty, recken and noumbre" (438. 439).

This shows that the introduction of the Arabian numerals, and the art of reckoning made possible by their use, was of recent introduction into Britain, where, in point of fact, merchants continued to employ Roman numerals in their accounts even in the sixteenth century. The old *abacus*, or counting frame, continued to be used down to the reign of Edward VI. The first of that long series of works which has been devoted to the extension of the knowledge of arithmetic in our country is due to the pen of a mathematician and physician, Robert Recorde, born in Tenby, 1500, who in his "Arithmetick, or the Ground of Artes," sought to popularize the new method of calculation. He thus speaks of his great theme :—" It is an Arte that the farther you travell the more you thirste to goe on forward. Such a fountaine that the more you draw the more it springes; and to speak absolutely in a word (exceptinge the study of Divinity, which is the salvation of our souls), there is no study in the world comparable to this for delight in wonderfull and goodly exercise; for the skill hereof is well known to have flowed from the wisdom of God into the heart of man, whome he hath created the chiefe image and instrument of His praise and glorie."* So he speaks of arithmetic pursued as an art founded on scientific principles. Practice in computation will make an active-minded boy, who knows how to use figures, so dexterous in the working of sums, that he can go on with machine-like regularity and certainty, turning out correct answers to long accounts, although he cannot explain the reasons for his operations, or prove the accuracy of the rules according to which he proceeds, and which justify his processes. Such an acquaintance with practical arithmetic is by no means useless or to be despised, but it only interests and employs one-half of the mental faculties. There is a pure pleasure felt by the higher powers of the mind in understanding the principles of things; and when reason is brought into active exercise while giving instructions on this subject, the development of the mind of the scholar is influenced by it. This is the disciplinary, as distinguished from the utilitarian, value of the study of arithmetic. Memory, imagination, and the management of figures are quite easily exercised in computation even when taught only as an art; but when it is pursued as a scientific system, it forms a highly useful agency in educating the reason and developing the faculties of comparison and deduction. Cunning riddles and curious puzzles have been incorporated with it, books of sums have been set to be laboriously drudged through, and large compendiums of methods of calculation have been arranged for exercising ingenuity and encouraging dexterity in numerical computation as an art. Knowing its value in the exchange and the market-place, in the industries of mechanical and the business of commercial life, aptitude in figuring has held a high place in men's regards. It has been decided on all hands that the youngest and the humblest should know something of its elements and have practice in its processes. It may subserve higher interests and gratify nobler inquiries than even these can afford opportunity for engaging in, when undertaken with the desire of knowing it as a readily available culture in deductive logic, and a familiar form through which to learn how theory regulates and benefits practice. The modern method of teaching arithmetic—introduced by Bourdon in France and De Morgan in England—which recognizes the importance of reason and demonstration in the course of instruction, has our fullest sympathy. It is not desirable that unexplained routine and merely empirical methods should constitute the whole of our arithmetical culture. Intellectual training may be combined with practical dexterity in "doing sums," and that too without any loss of variety in the exercises, or ingenuity in the working of them. The following lessons in arithmetic will explain fully and exemplify clearly the nature and reason of every process, and will form a complete course of practical, rational, and commercial arithmetic—useful at once to the business man and the self-educator.

1. The first ideas of arithmetic, as well as those of other sciences, are derived from early observation. Children compare objects, and finding that they differ in size, soon become familiar with the idea of *magnitude*. They collect together toys, and learn the meaning of *number* and *quantity*. Yet these are terms which it is not possible to define; the ideas for which they stand are so completely the first ideas of our mind that it is impossible to find other more simple words by which we may explain them.

2. To express the magnitude of a thing, or of a collection of things, all of the same kind, so as to convey a precise idea to others, we fix upon some part of that kind of thing the magnitude of which is well known, and state *how often* this portion is contained in the thing or the collection of things of which we speak. This portion fixed upon is called a *unit*, and is the base of measurement for things of its kind. Thus, for instance, when we say that a log is 12 feet long, or that a bar weighs 12 lbs., we state how often the known portion of length called a foot, or the known portion of weight called a pound, is contained in the length or weight referred to. In these cases the foot is taken as the unit of length, and the pound as the unit of weight; and the term which is used to express *how many times* the unit must be repeated to form a whole, equal to the magnitude spoken of, is what we denominate *number*.

3. In every particular classification of numbers the unit is a portion taken arbitrarily, or established by usage. Sometimes, indeed, there is something in the nature of the thing whose magnitude is to be expressed which makes us choose one unit rather than another. Thus, in stating the size of a crowd of people, of a drove of sheep, or of a fleet of ships, everybody would fix upon a single person, sheep, or ship as the unit. But often there is nothing to indicate what portion we ought to choose as our unit. This is particularly the case with weights and measures, where the units are fixed by the community who use them, and where in consequence every nation has its own set of units, and consequently its own system of weights and measures. But it is highly desirable that those quantities fixed upon as units should be as extensively used as possible, and especially that all units which bear the same name should be identically the same. For instance, we have two sorts of units of weight, bearing the name *pound*; it is therefore necessary in stating a weight of so many pounds to indicate at the same time whether the *avoirdupois* unit has been taken or the *troy* unit, or what is equally useful, to bear in mind what sort of articles are weighed with the one and with the other. The unit also must be of the same kind as the thing measured, for there can exist no measurable relations except between quantities of the same kind. It would, for instance, be obviously absurd to attempt to calculate the number of yards in a bushel, or how many gallons of wine there are in a load of coals.

4. A *unit* is a measure of any kind, natural or arbitrary, to which we refer everything of that kind, as 1 (one). A collection of units of the same kind constitute a *number*, as 10 (ten), 16 (sixteen), 40 (forty). Numbers may be expressed (1) by words, as nine; (2) by figures or digits, as 9. When the unit is restricted to a certain thing in particular, as one pound, one yard, one gallon, the assemblage of many of these units is called a *concrete* number, as *five* pounds, *seven* yards, &c. But when the unit does not denote any particular thing, and is expressed simply by *one*, the assemblage formed by collecting together several of such units is called an *abstract* number, as *five, seven*, &c. Every kind of concrete number has its particular unit or units, which being known the number itself is known; but it is obvious that all abstract numbers must be measured by the same unit, and are known as soon as named. *Notation* is the name given to the method we employ of writing down the

* Perhaps Recorde here reproduces an idea from the "Arithmetica" of Boethius, the last of the Roman philosophers, in which this passage occurs: "Arithmetic stands in a sort of maternal relation to all other sciences, because God, the founder of this earthly fabric, had it with Him originally as the exemplar of His own design, and framed according to it all things whatsoever, which—His reason comprehending these—found their harmony in the numbers of a pre-established harmony."

symbols or signs of numbers (figures) instead of the names of the numbers themselves.

To facilitate the management of numbers in arithmetic they are generally represented by certain arbitrary symbols,* which we call *figures*. Yet it is obviously impossible to have a distinct figure for every number, and accordingly a few only are chosen, and high numbers are represented by combining these according to certain rules. Ten such signs are employed in modern notation, and are given along with their names and meanings in the following table :—

Figures.	0	1	2	3	4	5	6	7	8	9
Names.	cipher	one	two	three	four	five	six	seven	eight	nine
Numbers represented.		.	..	...	.. ..	... ..	... ...	....	....	....

The method of so combining these few symbols as to make them represent numbers of every possible magnitude is, though usually learned with much difficulty, elegant and simple.

5. We have nine signs to stand for the first nine numbers, and the cipher to stand for *nothing*, or *zero*; but we have no separate sign for ten. Ten is therefore the limit of our separate symbols, and where we must begin to combine. There is really no absolute necessity for selecting one number rather than another as the limit of our simple numbers; but the early arithmeticians of India fixed upon ten, and the Arabians accepted their system, and spread a knowledge of it in Europe, where its superior simplicity was soon acknowledged, and has been everywhere adopted. If we recollect how apt we are, in our first essays in calculation, to count on the fingers, we shall be at no loss to infer the reason why ten has thus been fixed upon in preference to all other numbers. It might be accounted for in this way :—*One* finger being held up is represented by I., and this is repeated till *four* (IIII.) are held up. *Five* is then represented by a rude indication of the four fingers being held up with the thumb expanded, as V. Proceeding as before with the raising of the fingers till *eight* (VIII.) is reached; *ten* is represented by the hands being crossed, showing that the two sets of digits are to be taken together (or two Vs), as X. The arm bent at the elbow, representing *five tens* (= 50), is the original of L for *fifty*; and the two hands being brought nearly together in a curved form, indicating *ten tens* (= 100), supply the sign C. Another explanation is, however, given by Dean Peacock. The nine numbers were indicated by nine single strokes. On counting these up a transverse stroke was made across the next or tenth stroke, so forming X. One half of this X forms V, and signifies five. Two lines having been used to denote ten, three were taken to indicate *ten tens* (=100), thus, ⊏; but this in being rapidly formed took the shape C. *Ten times ten tens* was noted by four lines, M, which became the symbol for a thousand. The last two symbols being like the initials of *centum* and *mille* confirmed their use.

6. Suppose a man has some great number—as the number of revolutions made by the fly-wheel of a steam engine in a given time—to count; and suppose that, to help his memory, he holds up a finger for every one he counts, he can thus proceed as far as ten, and then must begin again to reckon the fingers a second time. In this way, by reckoning the fingers again and again, he might count off any number of tens; but this is not enough—he must also know the number of times he has had to begin again; that is, the number of tens he has counted. Suppose, then, that he places a person at his left, with instructions to hold up one finger each time he is ready to begin anew; that is, each time that a ten is reckoned. Each finger held up by the first man will simply denote one; but it is manifest that each finger held up by the second man, acting according to his instructions, will indicate a number equal to all the fingers of the first; that is, ten. Continuing the calculation until all the fingers of the second man are reckoned, and supposing the first man just ready to begin again, then the precise number counted is ten tens, and this is what we express by the term *one hundred*. Now, suppose a third man, placed at the left of the second, who holds up a finger whenever he perceives the second ready to begin again; this third man will keep an account of the number of hundreds that are reckoned. One of his fingers will indicate as many as all the ten fingers of the second, and his ten fingers will denote ten hundreds, and for this number we use the term *one thousand*. In this way, each of the fingers of a fourth man would indicate ten thousand; each of those of a fifth, a hundred thousand; and so on. Suppose, further, that the persons engaged are six in number, and that they relinquish their experiment at a time when the first man has seven fingers extended; the second, five; the third, four; the fourth, eight; the fifth, nine; the sixth, three: then, in order to find the whole number of revolutions counted, we might place the results in the following order :—

6th	5th	4th	3rd	2nd	1st	
					7	Seven ones, or seven.
				5	—	Five tens, or fifty.
			4	—	—	Four times ten tens, or four hundred.
		8	—	—	—	Eight times ten hundred, or eight thousand.
	9	—	—	—	—	Nine times ten thousand, or ninety thousand.
3	—	—	—	—	—	Three times one hundred thousand, or three hundred thousand.

The whole number reckoned is therefore *three hundred and ninety-eight thousand, four hundred and fifty-seven* (398,457).

7. The next question is, How may such a number be represented in a short and convenient form? This is still a matter of choice. We might denote the tens by marking their number with one accent, the hundreds by two accents, the thousands by three accents, and so on.

$$\text{Thus, } 3''''' \; 9'''' \; 8''' \; 4'' \; 5' \; 7, \text{ or } 7 \; 5' \; 4'' \; 8''' \; 9'''' \; 3'''''.$$

We might arrange the figures in any order; because their meaning would depend on the accents which are attached to them, and would have no relation to the place in which they stand. Adhering, however, to some determinate order, as,

$$3''''' \; 9'''' \; 8''' \; 4'' \; 5' \; 7,$$

it is readily seen that these accents are unnecessary and cumbersome. For, since the figure having the single accent will always stand in the second place from the right, that having the double accent, in the third place from the right, and so on, the *place* which each figure occupies will always point out what accents it should have; that is, whether it denotes ones (units), tens, hundreds, thousands, or any higher order. Thus, observing that the ones (7) occupy the place on the right, that the tens ($5'$) occupy the second place, the hundreds ($4''$) occupy the third place, and so on, each figure is sufficiently well known by the place in which it is; that is, by the number of figures which come upon the right of it. Thus, in 33333, each 3 stands for three of something, according to its place; the 3 on the right hand, for three pebbles (supposing pebbles to have been the things counted); the 3 in the second place, for three collections of ten pebbles each; the 3 in the third place, for three collections of one hundred each, and so on. From this and similar examples the rule is obvious: *each figure placed on the left of another assumes a value ten times greater than if it occupied the place of the latter.*

8. It may still appear that this rule is not applicable to such numbers as $3''' \; 5'' \; 6$, and that accents are still necessary to prevent such a number from being mistaken for $3'' \; 5' \; 6$, or the like. But this difficulty is removed by the using of the cipher to bring each figure to its proper place; that is, the place allotted to the sort of collection which it represents. Thus, $3''' \; 5'' \; 6$ may evidently be written, $3''' \; 0'' \; 5'' \; 0' \; 6$, for 0

*"A *symbol* is any sign for a quantity which is not the quantity itself. If a man count his sheep by pebbles, the pebbles would be symbols of the sheep. Our symbols are marks upon paper, of which the meaning of every one is determined as soon as the meaning of 1 is determined. They are, moreover, *arbitrary*; that is, any others would have done. It is 2 that stands for 1 and 1 taken together, and not <, >, V or anything else, because certain Hindus choose that it should be so."—*De Morgan*, "*Elements of Algebra.*"

means nothing, and has therefore in no other way affected the value of the number than by filling up the singly and trebly accented places which were vacant, there being no odd thousands or odd tens to denote. Leaving out the accents as before, the number is 30,506.

Similarly, 1′	is represented by		10
2″	"	"	200
3‴	"	"	3000
4⁗	"	"	40000
5′′′′′	"	"	500000

and so on, the ciphers serving to denote the order of the significant figures, exactly in the same manner as the accents.

9. When a number requires more than six figures to express it, then it is customary to divide it into periods of six figures each, reckoning from right to left, and to distinguish each by a peculiar name, as shown in the following table:—

BRITISH NUMERATION TABLE.*

I. Units	1 Units 2 Tens 3 Hundreds 4 Thousands 5 Tens of Thousands 6 Hundreds of Thousands
II. Millions . . .	7 Units 8 Tens 9 Hundreds 10 Thousands 11 Tens of Thousands 12 Hundreds of Thousands
III. Billions . . .	13 Units 14 Tens 15 Hundreds 16 Thousands 17 Tens of Thousands 18 Hundreds of Thousands
IV. Trillions . . .	19 Units 20 Tens 21 Hundreds 22 Thousands 23 Tens of Thousands 24 Hundreds of Thousands
V. Quadrillions . .	25 Units 26 Tens 27 Hundreds 28 Thousands 29 Tens of Thousands 30 Hundreds of Thousands
VI. Quintillions . .	31 Units 32 Tens 33 Hundreds 34 Thousands 35 Tens of Thousands 36 Hundreds of Thousands
&c.	&c.

* On the continent of Europe it is customary to reckon by periods of three figures each, as in the following table:—

CONTINENTAL NUMERATION TABLE.

I. Units	1 Units 2 Tens 3 Hundreds
II. Thousands	4 Units 5 Tens 6 Hundreds
III. Millions	7 Units 8 Tens 9 Hundreds
IV. Billions	10 Units 11 Tens 12 Hundreds
V. Trillions	13 Units 14 Tens 15 Hundreds
VI. Quadrillions	16 Units 17 Tens 18 Hundreds
&c.	&c.

The periods succeeding those contained in the table are *sextillions*, *septillions*, *octillions*, *nonillions*, and analogous names might be formed for still higher periods. Those given, however, are more than sufficient to express any number which it is ever necessary to designate in language.† Such, indeed, is the facility with which large numbers are expressed, both by figures and language, that we have generally a very imperfect conception of their real magnitudes or meanings.

10. There cannot be now much difficulty in enunciating any number already expressed in figures. If we take a number, as 67543, we observe that it is composed of 6 tens of thousands, 7 thousands, 5 hundreds, 4 tens, and 3 units, or 67 thousand 5 hundred and 43, or sixty-seven thousand five hundred and forty-three—which latter is the common form of enunciation. Again, 17060080, divided into periods, is 17,060,080, and may be read, 1 ten million, 7 millions, 6 ten thousands, 8 tens, or 17 million 60 thousand and 80, or seventeen million sixty thousand and eighty.

The following are other examples in illustration:—

Mills. Thous. Units.		
708,000, 906, 000	is read	Seven hundred and eight thousand millions, nine hundred and six thousand.
78,906, 000, 400		Seventy-eight thousand nine hundred and six millions, four hundred.
7,800, 600, 040		Seven thousand eight hundred millions, six hundred thousand and forty.
789, 060, 004		Seven hundred and eighty-nine millions sixty thousand and four.
78, 906, 000		Seventy-eight millions, nine hundred and six thousand.
7, 890, 600		Seven millions, eight hundred and ninety thousand, six hundred.
789, 060		Seven hundred and eighty-nine thousand and sixty.
78, 906		Seventy-eight thousand, nine hundred and six.
7, 890		Seven thousand, eight hundred and ninety.
789		Seven hundred and eighty-nine.

Arrange in a similar table the following numbers:—

106, 1803, 98769, 80567804, 207000080, 108365, 9007867, 8006783401, 999, 13, 25252, 896262711, 797, 38416, 4611564021, 34413, 6701, 6304803004, 8243422027, 49, 8529, 359, 9846, 694321, 14976271, 369409820459.

11. The expression of numbers by means of figures presents in reality no great difficulty; for, each period being enunciated and qualified, it only remains (1) to write each of them separately, and (2) give it the rank which its name indicates. In the first trials, however, it may be advisable to make as many points as the highest name requires, and to mark these off into periods; the significant figures may then be written in their places, under the dots, and the blanks filled with ciphers. Thus, supposing that the number to be written down is five hundred and six million eight thousand and nine, we know that the place of the hundreds of millions is the last of the third period; there must consequently be nine figures, or three periods, in the number, and we proceed accordingly to make three periods of dots—

Millions.			Thousands.			Units.		
·	·	·	·	·	·	·	·	·
5		6		8				9

and filling up the unoccupied places with ciphers, we get for the true expression of the number, 506,008,009. After a little practice the use of dots will be found unnecessary.

† We can pronounce readily the word *billion*, yet calculation informs us that there are not a billion of seconds in seven hundred and sixty-one thousand years. Our eight hundred millions of national debt would, if represented by ten-pound notes of the Bank of England, each only the hundredth part of an inch in thickness, form a pile nearly 13 miles high. To tell it in sovereigns, at the rate of 100 every minute, for twelve hours a day (Sundays included), would occupy one man for more than thirty years.

The following are examples of the same kind :—

Name.	Written.
Three hundred and nine, ...	309
Seven thousand and sixty, ...	7,060
Twenty thousand five hundred, ...	20,500
Two million one thousand and eleven, . . .	2,001,011
One hundred and two million five hundred and seventy-four, ...	102,000,574
Twenty thousand and one million forty thousand one hundred and forty-nine, . .	20,001,040,149

Write out in a similar form the figure-signs for

Five hundred and eighty-nine.
Three thousand and thirty-seven.
Sixty-four thousand and eleven.
One million two thousand and five.
Four hundred and forty-eight million.
Three million four thousand and eight.
Five billion seven thousand one hundred.
One hundred and sixty-three million and two.
Ninety-eight million three thousand four hundred.

12. The method of expressing numbers by figure-signs is termed *notation*, and the method of reading numbers so expressed is termed *numeration*. This system of numeration is based on these two considerations, (1) ten units of any lower order equal one unit of the next higher order, and (2) three orders of units form one unit of a higher order, which is therefore called a *ternary* period.

13. The method of numeration here described is denominated the *decimal system*, from the Latin word *decem*, ten ; because the value of the figures *increases* in a tenfold proportion from right to left, and consequently *decreases* in the same proportion from left to right. But besides this there are other systems in common use. For example, we measure wood, &c., by feet and inches, the foot being equal to 12 inches, and the inch to 12 parts ; that is, each superior name contains 12 units of its next inferior name; this system is therefore called the *duodecimal system* (from the Latin word *duodecim*, twelve). Our present mode of counting money is a mixture of systems. We divide it into pounds, shillings, and pence, of which 12 pence make a shilling and 20 shillings a pound. We write a number of pounds, shillings, and pence thus, £2 : 5 : 11, where £ shows that 2 is pounds, and as shillings is the next lower name, and pence the next in succession to shillings, the meanings of the 5 and the 11 are obvious. This variation in the value of the units renders the calculation of sums of money more complex than those with abstract numbers. The same is likewise true of our systems of weights and measures.

14. The systems of arithmetical notation employed by the ancients were exceedingly inconvenient and imperfect. They served laboriously to register a number that was not very great, but they could not aid in performing arithmetical computations.* In the simple calculations which it was absolutely necessary to make, recourse was had to some sort of mechanical contrivance, of which the *abacus* of the Romans and *swan-pan* of the Chinese are examples. To form a notion of such an instrument, suppose a board with a number of lines drawn upon it, as represented in the figure, and that each pebble or counter† placed on the space A denotes 1 ; each on the space B denotes 10 ; each on the space C denotes 100 ; and so on so that, taking the ciphers for counters, the number represented by their disposition in the figure will be 123142. The Romans made all their heavy calculations thus, and noted the results by the letters of their alphabet. This method of writing numbers we still retain for some purposes, as for marking the chapters of books, the year of the Christian era, hours on dial-plates, &c. The letters employed are I, to denote 1 ; V, 5 ; X, 10 ; L, 50 ; C, 100 ; D, 500 ; and M, 1000. (IƆ has the same meaning as D, and CIƆ as M.) These letters, when so used, are called *numerals*, and the principles upon which they are combined, so as to stand for intermediate and for higher numbers, are these :—

F	0
E	00
D	000
C	0
B	0000
A	00

(*a*) The repetition of a letter denotes the repetition of the number it represents; thus, III denotes three ones, XXX denotes three tens, &c.

(*b*) When a letter expressing a less number is placed *after* a greater, the values of the numerals are to be taken together. Thus XI means 10 and 1, or 11; LX means 50 and 10, or 60, &c.

(*c*) When a numeral of a less value is placed *before* one of greater, its value is to be deducted. Thus, IV means 5 *less* 1, or 4 ; XL means 50 *less* 10, or 40.

(*d*) When Ɔ is annexed to IƆ, it increases the value of that character ten times. Thus, IƆƆ is 5000, and IƆƆƆ is 50,000. In like manner, CIƆ is increased in value ten times by prefixing C and annexing Ɔ. Thus, CCIƆƆ is 10,000, and CCCIƆƆƆ is 100,000.

(*e*) Lastly, a line drawn *over* a numeral increases its value a thousand times. Thus $\overline{X}$ stands for 10,000.

The following table exhibits these particulars more fully :—

Units.		Tens.		Hundreds.		Thousands.	
I, ...	1	X, . . .	10	C, ...	100	M or CIƆ, ...	1000
II, ...	2	XX, . .	20	CC, ...	200	MM or $\overline{II}$, . . .	2000
III, . . .	3	XXX, .	30	CCC, ...	300	MMM or $\overline{III}$, . .	3000
IIII or IV,	4	XL, . .	40	CCCC or CD, .	400	MMMM or $\overline{IV}$, .	4000
V, ...	5	L, . . .	50	D or IƆ, . . .	500	IƆƆ or $\overline{V}$, . . .	5000
VI, ...	6	LX, . .	60	DC or IƆC, . .	600	IƆƆM or $\overline{VI}$, . .	6000
VII, . . .	7	LXX, .	70	DCC or IƆCC, .	700	IƆƆMM or $\overline{VII}$, .	7000
VIII, . . .	8	LXXX,	80	DCCC or IƆCCC,	800	IƆƆMMM or $\overline{VIII}$,	8000
IX, ...	9	XC, . .	90	CM, ...	900	IƆƆMMMM or $\overline{IX}$,	9000
				CCCCIƆƆƆƆ, ...		1,000,000.	

These particular cases of combination may be observed :—

XVII for . . .	17	DCCXIX for .	719	$\overline{VII}$CC for .	7,200
XXIV . . .	24	CDXC, or XD .	490	$\overline{XXX}$XC .	30,090
XXXIX . . .	39	MDCCCXLI	1841	CCIƆƆXL .	10,040

Express in Roman letters, 14, 27, 96, 109, 645, 9089, 5407; and in Arabic figures, XIV, XXXIX, XLV, XCIX, CXC, CCCXI, DLX, DXCIV, MDCCCXCIX, $\overline{VIII}$, $\overline{LX}$DCVI.

LATIN.—CHAPTER I.

THE LATIN LANGUAGE—THE LANGUAGE AND LITERATURE OF ROME—CLASSICAL LEARNING AND STUDIES.

The Latin language was spoken by the Romans. It is a member of that amalgamating type of languages formerly called Indo-Germanic or Indo-European, but now usually termed Aryan. By sameness of root-stems and similarity of structure it is closely related to Celtic, Persian, Greek, German, and English. A great race, known in history as Pelasgians, appear, at an early date, to have spread over Greece and Italy. At some remote period these adventurers, descending from the Central Apennines to the lands watered by the Liris and the Tiber, formed a settlement in Latium. These hardy, warlike, frugal immigrants soon formed themselves into townships, and exerted authority and influence over the farm-lands surrounding their municipalities. Rome ultimately became the head of a confederacy of these settlers. The supremacy it acquired was practically political, and the sway it wielded was recognized as Roman. The speech of the people occupying the Latian territory gradually fitted itself to be an instrument for communicating thought and transacting business, and from the name of the prevailing tribe it got the name of Latin. At first it was only used in Middle Italy. Subsequently it gained currency in the whole peninsula ; and,

* This may be easily shown to be the case by stating a simple sum in this notation, *e.g.* multiply MDCCCLXXXVI. by CCCLXV. (1886 × 365). It is a fact, too, that in the history of the Roman people we have no evidence that arithmetic, though practised as an art, was ever studied as a science.

† The word *calculation* is derived from *calculus*, a pebble, pebbles being originally used on the abacus. In process of luxury, *tali* or little oblong dies made of ivory were used instead of pebbles, and small silver coins instead of counters.

as the conquests of the mother-city extended, it penetrated into every Roman province. France, Spain, Portugal, Belgium, parts of Germany and Britain, spoke the language of Rome.

Owing to the constant accession of new allies and fresh tributaries, and to the consequent influx of strangers into Rome and Roman intercourse with those who employed a different vernacular, the Latin language long remained unformed, imperfect, and unsettled; and even after its acceptance as the conventional speech of the agglomerated masses brought under its dominion, it was a long time before it adopted the conscious polish of art, or attained, by the refining elaboration of genius, the grace which the imitation of Greece ultimately gave it. Even in Rome, and still more so in the outlying parts of the peninsula and the western provinces, the Latin language presented itself in two forms—(1) a folk-speech or vulgar vernacular—a rude and indigested, every-day, go-to-market, and colloquial one; and (2) a polished, fashionable, cultured tongue—the speech of good society and of books. From the former, in later times, the Romance or Romanic languages—Italian, Spanish, Portuguese, French, &c.—took their origin; the latter developed into the language employed in those writings which are now by pre-eminence called Classics, and form the main body of Latin literature.

As Rome consolidated into a community, and men's interests converged towards that great centre of power, the surrounding people studied the speech of their masterful neighbours, of whom they were soon to be made the fellow-subjects. When wealth gave leisure for culture and exerted a desire for things of worth and grace, the Romans began to seek after luxury of language, and the taste for study stirred their nobler spirits. Greece had provided the most perfect and pellucid language for the expression of thought and emotion which the world knew. Its grammar was made the model of sentence-building, and the works of the Greek poets, dramatists, philosophers, and historians inspired imitation and aroused emulation. Greek teachers abounded in Rome, and the language of culture afforded the pattern upon which the language of practical power was moulded. The meagre, uncouth, and ill-arranged dialects of the differing tribes—Etruscan, Umbrian, Sabine, and Oscan—which had compacted themselves and coalesced into a practically interchangeable means of communicating ideas and desires, and had assumed the character of a folk-speech among those whom trade, interest, friendliness, or power had brought together, were now subjected to conscious culture. The common people used and understood the current phraseology. Conversation, ballad, oration, inscription, proclamation, and law induced a widening of the area over which the Roman speech extended, and as migration decreased the sway of Rome increased. This was the period in which the materials of the language were collected and the spirit of life was giving it form. Of its condition in these early times we can acquire some idea from the Salian Hymns, which the priests of Mars chanted as they moved in procession through the city. These verses—of which only stray snatches now remain—are attributed to the age of Romulus; but, as we learn from Quintilian (I., iii. 4), they were scarcely understood even in his day by the priests who sang them. The Laws of the Twelve Tables, the inscriptions on the mausoleum of the Scipios, and several other fragments of ancient Latin writing, show us the colloquial and dialectical state of the language undergoing gradual refinement and polish, growing less rustic and plebeian, more urbane and cultured.

For nearly five centuries, indeed, after the foundation of Rome (753 B.C.), no literature of any notable value was produced by the Latin races. They were, it may be, too busy in making to spend energy in writing history; and they perhaps experienced rather than troubled themselves with reproducing poetical emotion. They were active, intelligent, passionate, and ultimately patriotic, and must doubtless have felt the flame, if they did not enjoy the glow, of poetry. Hymns they had. Songs, ballads, folk-rhymes, wise saws, and perhaps rude dramatic entertainments almost certainly existed among them; but it was not till war, agriculture, and polity had won many conquests that they essayed to add literature to their employments and enjoyments. And when literature did arise it was rather as an exotic, cultured by literary men after Greek models, than as an indigenous product, that it took its place among the pleasures of Roman life.

During the seven centuries and a half of its existence as a living speech—oral rather than written—it of course underwent considerable changes. It gained and lost, absorbed and parted with words. The meaning of many of its vocables changed, and the grammatical structure of its sentences varied. Even its alphabet and its pronunciation underwent alteration. These changes occasion some difficulty in the study of Latin now; for they require notice as archaisms, exceptions, &c., while reading, and when endeavouring to understand the works of writers whose compositions, in general, adhere to grammatical form. In fact, the syntactic Latin of social conversation and literature was quite an artificial language, and probably differed very widely from the colloquial speech made use of by the common people on farms, at market, and in workshop. Under Greek influence, and owing to the prevailing power of the polity of Rome, Latin assumed a literary form, was cultured and developed, and attained the character of a national language. The first important direct step in bringing Latin literature into being was taken by Livius Andronicus, a freed slave of Hellenic descent, who imitated or translated the dramas of Greece into the language of Rome about 230 B.C. A more celebrated poet than he, however, may be regarded as the real founder of literary Latin—Quintus Ennius, a Calabrian, master of three languages, Greek, Oscan, and Latin, who was brought by Cato the Elder from Sardinia to Rome as a Greek tutor. He induced the Romans to study as models the productions of "Magistra Græcia" (Greece the Instructress), encouraged the emulation of them among the Latin patricians, and wrote himself a Chronicle in verse, which set in hexameters the traditions of the people among whom he dwelt, and transforming the old national lays and legends into epic poetry, gave to Roman literature a noble impulse and a notable first-fruit.

The literature of Greece had itself begun to decline when the Romans felt and recognized the influence of its orators, poets, historians, and grammarians. Strong as was their national character, great as was their respect for the practices of their ancestors, and decided as their interest in politics and warfare was, yet the better dispositioned and the more intellectual among them became animated with a liking for the culture which had made Greece famous. They studied with zeal the works of the great Greek authors, and entered with zest into the grammatical, historical, critical, and philosophical investigations, to a consideration of which these invited them. Admiration led to imitation. In much, they too slavishly followed the path taken by their predecessors, and perhaps there is a want of freshness and originality in their efforts. They did not strike out any essentially new forms, although they certainly moulded their language into better style than before. The *Axămenta* (hymns) of the Salian priesthood, the rural lays of the Ambarvalian brethren, the old convivial songs, and the harvest-home rhymes, as well as the rude satiric and dramatic poems which were improvised or recited at merrymakings, gave way before poems and dramas composed in Greek metres and translated from Greek authors. The annual notices of events prepared by the *pontifex maximus*, the *fasti* or accounts of the persons who had been elected to the office of the magistracy, the *laudationes* or funeral orations, and the commentaries of the priests concerning the national worship—which seldom arrived at excellence of style—were found to fade in interest before the legendary tales, and the historic records to which, in imitation of the Greeks, Rome began to devote attention. People of distinction took under their care teachers of science and philosophy. Grammar and rhetoric became favourite studies, and indeed imparted their tone to the whole of Roman literature. Crates Mallotes, B.C. 168, first fairly imbued the Latin mind with the love of making critical inquiries concerning the laws and felicities of language. M. Terentius Varro, born 116 B.C., composed a grammatical work in twenty-four books, "De Lingua Latina."

From the Building of Rome to 240 B.C. may be regarded as the first period of Latin literature, when it was only rude, uncouth, and elementary, with few discoverable attractions; and little of value, either in form or matter, has come down

to us thence among the vestiges of antiquity. The second period, beginning from 240 B.C. and continuing to the time of Cicero, has given us some better specimens of literary effort. Time has not spared the translation of the "Odyssey" or the comedies and tragedies which Livius Andronicus wrote; he has only left us a few detached fragments of the poems of Ennius, whose annalistic epic "lived on the lips of all the Latin race" for years; but he has handed on along the centuries twenty of the transfusions of the Greek drama into the Latin tongue which Rome owed to M. Attius Plautus, and six of those comedies, adapted freely from Menander, Apollodōrus, and Diphilos, with which P. Terentius Afer enriched the Roman stage. The writings of the annalists and jurists have been lost, but the treatise on agriculture by M. Porcius Cato Censorius has survived—though evidently redacted and modernized—to show us how farms were managed and rustic affairs went on in the *iron age* of Rome's literature.

In the *golden age* which succeeded and extended through the century 75 B.C. to 25 A.D. learning became increasingly essential to polished life. Education was promoted by the establishment of schools, and public as well as private libraries were multiplied not only in Rome but in many parts of Italy. Powerful patrons of culture—like Mæcenas and Asinius Pollio—arose. Amid all the excitement and confusion of social and civil war, literature, as a solace in misery and an occupation favourable to forgetfulness of the irksome present in an imaginary past or an ideal future, quickened many minds. The romance of personal heroism and adventure in which Greek epic poetry expended itself became in the Roman the romance of national progress and power. The larger destinies of Rome, as the missionary mistress of the world, had in some measure awakened the mind of Virgil—though it was rather an aspiration than an expectation. Poetry intertwined itself with all human life, and in odes and songs triumphed and was glad; in elegies, mourned or meditated; in epistles and satires, reflected on human life and man's pursuits; in bucolics, delineated pastoral activities and pleasures, and moulded the words of wisdom into fables and epigrams. Lucretius, with true poetic fire, explained, defended, and glorified the doctrines of Epicurus; Ovid, with fancy, wit, and versatility, set the myths of Greece in a Roman framework; Horace and Catullus wrought nature, truth, taste, feeling, and the simpler emotions of human life into ever-during song. In prose literature Livy vied with Herodotus, while Cicero emulated Plato, and Brutus Demosthenes; Sallust, Cæsar, and Livy made history a charm and a lesson. The literature of Rome was vital in this age. To the early part of this period belongs the introduction of scholastic grammar by Dionysius Thrax. He gave the "accidence" the form it even yet bears, arranged its declension tables for nouns and its paradigm models for verbs, defined the parts of speech, and formulated syntax. His system became the study of the learned, and inwrought itself with all literature as the regulator of Roman composition. All the writers *melioris ævi et notæ* (of the better period and the higher mark) accepted his laws as guides, and the grammarians took rank as the teachers of the arts of speech. Varro, Cnipho, and Verrius Flaccus also wrote on grammar and other topics of interest.

The next period, the *silver age*, shows a decline in literary power, though there was a more widely diffused desire for literary fame. Grammar overpowered genius. The formation of sentences received greater attention than the information they supplied. Intellectual poverty was concealed by rhetorical ornament. The political power of oratory had passed away, but the passion for declamation survived. The theory of culture spread, the glory of genius faded. Liberty lost, despotism triumphant, far-fetched artifices of style prevalent, and might of mind consigned to privacy of life or degraded into servility of condition, marked the period between the death of Germanicus at Antioch, 19 A.D., and that of Marcus Aurelius, 180 A.D. Phædrus the fabulist, Juvenal and Persius the satirists, Lucan, Silius Italicus, Valerius Flaccus, and P. Papiricus Statius the epicists, and Martial the epigrammatist, are the chief poets of this time. Tacitus, Paterculus, Valerius Maximus, Curtius, Florus, and Suetonius, are the chief names among its historians. Quinctilian wrote on oratorical education with profound learning and excellent taste; Columella discoursed *de re rustica*—husbandry, farming, gardening, rural economy, &c.; Celsus wrote on medicine; and the two Plinys—Plinius Secundus Major (23–79) and his nephew Plinius Cæcilius Secundus (62–110)—are represented to us mainly in the "Historia Naturalis" and a panegyric on Trajan, together with an admirable collection of letters.

From the time of the Antonines to the fall of the Western Empire literature declined rapidly. The purity of the language was lost; provincialisms crept in; display was more sought than wisdom. Although Aulus Gellius, Pomponius Festus, and Ælius Donatus kept systematic grammar before writers and speakers, the language grew corrupt and got disorganized. Ausonius and Prudentius have some repute among poets; Justin, Eutropius, Aurelius, and Orosius, engaged in historical compilation; Lucius Apuleius was perhaps the most able literary man under the Antonines. He was versed in all the learning of his age, he had a fertile imagination and a fluent style, though it was disfigured by inflation and turgidity. Boethius was the last, and by no means the least, of the literary writers of Latin; while Macrobius contributed somewhat to cosmography and philosophy.

After this the language grew less and less systematic, and the literature took more and more the form of compilation. Priscian, the illustrious grammarian (468–562), strove against the declension of Roman literary art both by precept and example. He composed poems, treatises, and tractates, which were most influential upon the culture of the middle ages, and are even yet of great value. Classical literature now began to pass away, and that language which, resulting from the confluence of races in the central region of Latium, had acquired dominancy over the peoples of many lands, corrupted by the Gothic invasions and the native languages of the tribes which occupied the outer parts of the empire, ceased to be the spoken tongue (*lingua Latina*) of the dismembered Latian state, and became the written medium of communication among the learned. It remained so till the revival of letters, and since then, by constant renovation of its purity from the fountain-sources of the noblest minds of Rome, it has continued to be the language of culture in all countries.

Of the Latin language, apart from its literature, we have little knowledge and slight means of learning its peculiarities as a speech. It is as a language complete and distinct, contained in books and available as a culture, that we know it. The Romans were a monarch race. Their thoughts and deeds, laws and mode of life, are recorded for us in their imperial tongue. Greek, indeed, came laden with literature, science, and wisdom—eventually, too, with the highest and holiest wisdom—into Rome, but Rome gave these universality and power. Latin was the speech in which they were made the common possession of all Western Europe. Latin learning was the ladder of life. The boy who knew it could be statesman, lawyer, or ecclesiastic. It became the groundwork of education as it was the mother of the living tongues of all nations. It was the language of all purposeful thought and effort, of power and influence—until scholasticism spoiled it. When the dark ages passed away, and the natural vigour of the spirit regained breathing-power among men, culture recalled Latin into the studies of the school.

Dante, Boccaccio, and Petrarch were taken captive by the rotund sonorousness of the verse of Virgil, the lyric grace of Horace, and the musical march of Cicero's sentences. The fall of Constantinople brought Greek into the West as a living tongue, and made Latin the speech of polite society. Life was made brighter and converse more engaging by the resuscitation of learning. It however tended to dilettanteism in Italy, but it was made earnest in Germany and France. It induced in the former of these countries that marvellous capacity for taking pains for which the Germans are distinguished, and in the latter that attention to elegancy and grace with which the French seek to invest all things. The noble and graceful literature of the ancients became the agent of spiritual life. They read, wrote, spoke, and sung Latin. Agricola thought that Latium itself could not be more Latin than Germany was. "A good strong reform" was advocated then, not only in religion, but in the schools.

Melancthon was the preceptor, and Sturmius the schoolmaster, of the Latin revival. In the higher general culture of Germany the discipline of learning Latin holds an important place. By Francis I., the "father of French literature," the three principal tongues—Hebrew, Greek, and Latin—were made the foundation-studies of the learned. They remained so till the Revolution, and in the organization of the schools—though the discipline of exact science has been added to the curriculum—literary culture is still pursued through Latin. Humanism and realism are allied, and Latin literature is co-equalled in school with science and socially serviceable studies.

In our own land we were brought into relation with Latin literature in its prime. Julius Cæsar, whose style is remarkable for ease, simplicity, and good taste, and who was one of the most cultured of the Romans—in grammar, politics, poetry, as well as in history—brought us under the wings of the Roman eagle. Quintus, the brother of Marcus Tullius Cicero, not less cultured than the orator, followed Cæsar into Britain, and both Cæsar and he wrote thence to Tully their impressions of those whom Catullus called "furthest Britain's fearful race." Diodorus Siculus and Strabo carefully collected all that the Romans had learned of the geography of "distant Britain." The famous pen of Tacitus has written part of our early records, in his pregnant yet elaborate manner, in the "Life of Agricola," and has thrown the charm of his pellucid narrative around the romantic stories of Caractacus, Boadicea, and Galgacus. Dion Cassius and Herodian carry on our island's story till the death of Severus—after building the wall between the Tyne and the Solway—at York, 211. Eumenius, the secretary to and panegyrist of Constantius Chlorus, eulogizes the heroism and beneficence of his patron in Britain, and in the funeral oration delivered in honour of Constantine the Great, congratulates Britain as happier than all lands in having first set eyes upon the Cæsar Constantine! By the rhetorical torchlight of another panegyrist—Libanius of Antioch—we see the expedition of Constans into Britain in a gleam of words. Ammianus Marcellinus gives account of proceedings taken by Paulus, a notary, against the British who had espoused the cause of Magnentius against Constantius III., son of Constantine, and of an expedition undertaken by Theodosius (afterwards emperor) to Britain. Claudius Claudianus, the last of the classic Roman poets, the client of Stilicho, celebrates his patron's prowess as the protector of Britain in the reign of Honorius, emperor of the West. By Augustine Britain was Christianized, and the church, with its official Latin and its Roman culture, acquired power. The monks of England sought spiritual and intellectual nourishment from Rome, and Latin, as the common language of the learned, was used by all studious men. The conventional speech of the republic of letters was cultured in our country under all those influences which mould the thinkers of an age, and lead them to write that they may be read.

Under Roman rule, so early even as under Agricola, schools were established and maintained for the study of the Latin tongue. Gildas, the wise, our earliest historian, wrote in Latin. Of the "Historia Britonum" of Nennius or Ninian, we probably have only an abridgment extant. Aldhelm, Bede, and Boniface were English writers of Latin. A great deal of Latin poetry was composed by British authors, and much of it is, in the structure of the verse and choice of words, polished and harmonious. Our most valuable treasures in the Latin tongue are historical works—a considerable number of which have been published by the Historical Society, under the direction of the Master of the Rolls, and in several collections. There are, besides these, a number of monastic registers, law treatises, public rolls, and the Domesday Book, as evidences of the hold that Latin had in the British islands.

In these early times none but the clergy were engaged in the business of instruction. The Romans set the example of having grammar-schools in the chief towns in the empire, and the church attached schools to all its monasteries and cathedrals. Everywhere, of course, in these schools Greek and Latin, as the learned languages, were taught. To the *grammatici*—teachers of grammar—the masterships of these schools were intrusted, and by them the educational impulses of the church and of the municipalities were guided. It was felt that the ancient languages, "by their facility of transposition, their compression of monosyllables, and their laws of complex construction," furnish the scholar with the purest and noblest forms of expression; that they are "the master-keys that unlock the noblest tongues of modern Europe;" that the severe regularity of their accidence and syntax are disciplinary in mechanism of phrase and structure of speech; and that they introduce the mind not only to treasures of words, but treasures of knowledge, of thought, and of mental force. Grammar is the logic of spoken thought; philology is the philosophy of the human mind written out in words and developed into principles. In modern languages all this is changed, and the authority of usage is paramount. In Latin the ages of flux are over. The language is fixed; its forms are no longer liable to alteration, and hence its utility in enabling the student to gain by experiment a knowledge of the relations between thoughts and words.

The study of Latin is like taking lessons in intellectual athletics. It is a drill which exercises memory, judgment, taste, classification, induction and deduction, sagacity and precision. It sets the mind to perceive distinctions and make selections of the choicest, most varied, and the most effective words and sentence-moulds. There is the translator's dexterity in bringing out the perfect and entire equivalence of phrase and sense; and there is the versionist's special sagacity in transforming the sense of our expression into the precise terms and tasteful forms of another tongue. We learn to apply a touchstone to words and sentences, and to test by the keenly-exercised perceptions of cultured intelligence the fitness of thought and word.

Grammar is the formal analysis of the usages of the best writers in any language, in order that we may derive thence a series of guiding-rules regarding inflexions, &c., and distinct directions concerning the logical relations—*i.e.* the syntax—of words. It observes, registers, classifies, and arranges the facts and phenomena of language; and having done so, it places the results of the investigations of patient and observant men before us. The purpose of doing so is that we may more accurately know and more readily imitate these things than we could do in our own casual and incidental observations in reading, hearing, or speaking. Latin grammar is a series of lessons so prepared and arranged that the learner may, by the help of his teacher, see most clearly and acquire in the briefest time the main facts of the language, and be supplied with such information as shall enable him, profiting from the studies of others, to acquire a knowledge of the language of Rome in a plain, easy, correct, and expeditious way. At least this is the aim of the lessons in the Latin language to which we now invite the attention of our readers. They shall aim, by conversational hints, wherever difficulties appear, to aid the student, while they endeavour, by clear, concise, and exact statement and arrangement, to give a full and satisfactory course of instruction to those who follow the directions and observe their requirements.

CHAPTER II.

ORTHOGRAPHY AND ACCIDENCE.

The use of words is to make known to others what passes in our minds. Grammar is the science which teaches us the way to use words properly. It generally does so by providing us with rules and examples. Rules fix what we are to do, and examples show us how the rules are to be obeyed and employed in practice.

The parts of speech are words. The elements of words are letters. The letters used in Latin are the same as in English—except that *w* and *k* occur in no purely Latin word. *Y* and *z* occur only in Greek words, and originally the same form of letter was used for *i* and *j* and *v* and *u*. The consonants are now generally pronounced as in English—only that *c* (= *k*), and *g*, *s*, *t*, and *x* are always hard, as in our words *cannon*, *get*, *season*, *tone*, *axe*. *J* has a sound somewhat broader than that of *y* in *your*. *Qu* sounds *koo*. *R* is distinctly heard.

The vowels are sounded thus:—*a*, as in *father; e*, as *ey* in *prey; i*, as *ee*, or *i* in *caprice; o*, as in *bone; u*, as *oo* in

soon; *y*, like *u* in *use*. The following mnemonic line gives the short and long sound of each of the vowels:—"Quīnīne, dĕmēsne, păpā, prŏpōse, Zūlū." When two vowels come together and are blended in pronunciation, they form a diphthong ("double-sound"). The diphthongs are *ei*, *œ*, *æ*, *eu*, and *au*. Vowels may be, 1st, by nature (1) short, as *ămŏr*, love; (2) long, as *ēsū*, eating; and, 2nd, by position (1) short, before another vowel, as *pĭus*; (2) long before two consonants or a double consonant, *pērdīx*. All diphthongs are long. The sign diæresis (¨) indicates that two vowels coming together do not form a diphthong, but are to be regarded as two syllables.

The consonants *b*, *c*, *d*, *f*, *g*, *h*, *j*, *p*, *q*, *t*, *v*, are called mutes, and are of three classes: (1) labials, *b*, *p*, *f*, *v*; (2) dentals, *d*, *t*, *j*; and (3) palatals, *c*, *g*, *h*, *q*. *G*, *d*, and *b* are called medial; *b*, *t*, *p*, thin; and *h*, *f*, *v*, aspirate. Mutes of different classes cannot come together unless the second is a dental. Hence, when mutes of different classes—the second not being a dental—come together, the former mute is changed into the latter: *ad-fligo*, *affligo*; *sub-gero*, *suggero*; and when mutes—either of the same or of different classes—come together, they must be of the same quality, *i.e.* medial to medial, and thin to thin: *ad-traho*, *attraho*. Though these rules hold generally there are many exceptions. *L*, *m*, *n*, *r*, are called liquids. *N* allies itself to the dental mutes, *m* to the labial. When *n* precedes a labial it is changed into *m*, thus *in-peto* becomes *impeto*; and when it precedes another liquid it is assimilated to it, so *con-moveo* is made *commoveo*. The sibilant *s* requires great care to secure euphonic composition.

The parts of speech are eight—viz., substantive or noun, adjective, pronoun, verb, adverb, preposition, conjunction, and interjection. Of these the former four undergo inflexion, the latter are uninflected.

There is no article in Latin, and hence *rosa* may mean either rose, a rose, or the rose. Other nouns are similarly undefined. Latin differs from English by employing additions to or changes in the terminations of words to denote a variety of circumstances, which we indicate by separate words or by changes in the positions of words. Thus we say "By the love of power," but the Romans said *amore potentiæ*, where *e* implies *by*, and *æ of*. Again, if we say "The master loves the slave," and "The slave loves the master," we change the position of the words to express our meaning; but the Romans did so by changing the terminations (inflexions) of the words, using for the former *Magister servum amat*, and for the latter *Magistrum servus amat*. The changes made in the terminations of words are called *inflexions*. That part of grammar which informs us of the changes of inflexion which take place in words to show their relation one to another is called *accidence*. The inflexions of nouns, adjectives, and pronouns are called *declension*; of verbs, *conjugation*. There are two numbers—singular and plural; and three genders—masculine, feminine, and neuter. There are five declensions, which are distinguished one from the other by the terminations of the genitive singular. These are, 1st, *æ*; 2nd, *ī*; 3rd, *is*; 4th, *ūs*; and 5th, *ēi*. A word made up of a noun with any one of the suffixes or terminations having an influence on the meaning of the word, is said to be in a certain *case*, and each case is distinguished by a particular name. Nouns are declined by adding the terminations of the several cases to the stem. The stem, in inflected nouns, is found by dropping the termination from the genitive singular, *e.g.* gen. sing. *sermon-is*; stem, *sermon*; or, more accurately still, when it is known, by casting off *-rum* of the genitive plural in the First, Second, and Fifth Declensions; *-um* in the Third and Fourth. There are in the singular and plural numbers six cases each, viz. nominative, genitive, dative, accusative, vocative, and ablative.

The fundamental case, that which names the subject of a sentence, is the *nominative*.

The case which indicates production, possession, &c., is called the *genitive*.

The case of indirect influence (of giving something to another) is the *dative*.

The case of direct influence, action, or reception, is the *accusative*.

The case of direct address (or apostrophe) is the *vocative*.

The case of circumstance, means, agency, &c., is the *ablative*.

1. The vocative case, in both singular and plural, is like the nominative, except in the singular of nouns of the Second Declension in *us*, in which the vocative ends in *e*.

2. The dative and ablative plural are always alike.

3. In neuter nouns the nominative, accusative, and vocative are alike in the singular; in the plural they are also alike, and end always in *ă*.

4. The genitive and dative singular are alike in nouns of the First and Fifth Declension.

5. The dative and ablative are alike in the singular of nouns of the Second Declension.

6. The nominative, accusative, and vocative plural of nouns in the Third, Fourth, and Fifth Declensions are alike.

In the First and Fifth Declensions there are no neuter nouns.

One of the most important things requiring attention in the study of Latin is to know the signification of the various terminations which constitute declension and conjugation. To learn this in regard to nouns we must acquire a knowledge of the changes which take place in the terminations of nouns of each declension.

Nouns of the First Declension have the nominative termination in *a*, and are mostly feminine, as *rosa*, a rose.

The nominative of nouns of the Second Declension ends in *us* or *er* (masculine), as *dominus*, a lord; *magister*, a master; and in *um* (neuter), as *regnum*, a kingdom.

Nouns of the Third Declension have many different endings for the nominative, and the genitive is formed in a great many different ways. It is the most variable and difficult of all the declensions. The terminations, together with their genitive forms, will be found in a reference table on page 41.

The nominative terminations of nouns of the Fourth Declension are *us* (masculine) and *u* (neuter).

In the Fifth Declension the nominative of all the nouns ends in *es* (nearly all are feminine).

Some proper names and a few other nouns, taken without alteration from the Greek, are declined differently; but these, and a few irregular nouns, need not trouble the learner now.

To decline a noun properly we require to know the nominative and the genitive cases; the former that we may know *what* to decline, the latter that we may know *how* to decline it. Cases are the forms which nouns assume in order to show the relations or circumstances of the object which the noun names; for it may (1) act, (2) possess or produce, (3) accompany, (4) be acted upon, (5) be addressed, or (6) be an instrument, agent, or means. Number shows whether one object (singular) or more than one (plural) is spoken of.

The declension of a noun is stating it in all its cases.

Every declinable word may be considered as consisting of two distinct parts, (1) the *stem*, and (2) the *inflexion*. The stem is that part which remains unchanged; the inflexion that which undergoes change. To the stem the case-endings are affixed when declining a noun.

In Latin many sexless things are in imagination considered as having sex, and hence every noun is either masculine, feminine, or neuter, and thus gender is often arbitrary. Nouns which may be either masculine or feminine are called (1) *common* or (2) *epicene*; as, *passer*, m., sparrow; *vulpes*, f., fox. Sex in such nouns must be indicated, if needful, by the words *mas*, *femina*; as, *passer femina*, a hen-sparrow; *vulpes mas*, a dog-fox.

Indeclinable nouns are neuter.

The most common rules regarding the gender of Latin nouns have been put into rhyme in the following lines—to the statements made in which there are, however, many exceptions:—

"Winds, Rivers, Males, and Mountains are, we find,
With Months and Nations, *masculine* declined;
But Countries, Cities, Females, Trees, we name
As *feminine*; most Islands are the same.
Common are such as may both genders take;
Words undeclined at all we *neuter* make."

In the following lists of nouns the gender is accurately indicated, and should be carefully learned along with the meanings.

I. Examples of the Declension of Regular Nouns, Masculine and Feminine.

Singular.	1st Declension		2nd Declension.		3rd Declension		4th Declension.		5th Declension.	
Nom.	Ros-ă, *f.*	*a rose.*	Serv-ŭs, *m.*	*a slave.*	Sermo, *m.*	*a speech.*	Fluct-ŭs, *m.*	*a wave.*	Di-ēs, *m. f.*,	*a day.*
Gen.	Ros-æ,	*of a rose.*	Serv-ī,	*of a slave.*	Sermōn-is,	*of a speech.*	Fluct-ūs,	*of a wave.*	Di-ēī,	*of a day.**
Dat.	Ros-æ,	*to a rose.*	Serv-ō,	*to a slave.*	Sermon-ī,	*to a speech.*	Fluct-ŭī,	*to a wave.*	Di-ēī,	*to a day.**
Acc.	Ros-am,	*a rose.*	Serv-um,	*a slave.*	Sermon-em,	*a speech.*	Fluct-um,	*a wave.*	Di-em,	*a day.*
Voc.	Ros-ă,	*O rose.*	Serv-ĕ,	*O slave.*	Sermo,	*O speech.*	Fluct-ŭs,	*O wave.*	Di-ēs,	*O day.*
Abl.	Ros-ā,	*with, from,* or *by a rose.*	Serv-ō,	*with a slave.*	Sermon-ĕ,	*with a speech.*	Fluct-ū,	*with a wave.*	Di-ē,	*with a day*
Plural.										
Nom.	Ros-æ,	*roses.*	Serv-ī,	*slaves.*	Sermon-ēs,	*speeches.*	Fluct-ūs,	*waves.*	Di-ēs,	*days.*
Gen.	Ros-ārum,	*of roses.*	Serv-ōrum,	*of slaves.*	Sermon-um,	*of speeches.*	Fluct-ŭum,	*of waves.*	Di-ērum,	*of days.*
Dat.	Ros-īs,	*to roses.*	Serv-īs,	*to slaves.*	Sermon-ĭbŭs,	*to speeches.*	Fluct-ĭbŭs,	*to waves.*	Di-ēbŭs,	*to days.*
Acc.	Ros-ās,	*roses.*	Serv-ōs,	*slaves.*	Sermon-ēs,	*speeches.*	Fluct-ūs,	*waves.*	Di-ēs,	*days.*
Voc.	Ros-æ,	*O roses.*	Serv-ī,	*O slaves.*	Sermon-ēs,	*O speeches.*	Fluct-ūs,	*O waves.*	Di-ēs,	*O days.*
Abl.	Ros-īs,	*with, from,* or *by roses.*	Serv-īs,	*with slaves.*	Sermon-ĭbŭs,	*with speeches.*	Fluct-ĭbŭs,	*with waves.*	Di-ēbŭs,	*with days.*

* If *e* in Genitive and Dative follows a vowel, it is *long;* if a consonant, *short*, e.g. *faciēi, fidĕi.*

II. Neuter.

Singular.	2nd Declension.		3rd Declension.				4th Declension.	
Nom.	Don-um,	*a gift.*	Corpŭs,	*a body.*	Anĭmăl,	*an animal.*	Corn-ū,	*a horn.*
Gen.	Don-ī,	*of a gift.*	Corpŏr-ĭs,	*of a body.*	Anĭmāl-ĭs,	*of an animal.*	Corn-ūs,	*of a horn.*
Dat.	Don-ō,	*to a gift.*	Corpŏr-ī,	*to a body.*	Anĭmāl-ī,	*to an animal.*	Corn-ū,	*to a horn.*
Acc.	Don-um,	*a gift.*	Corpŭs,	*a body.*	Anĭmăl,	*an animal.*	Corn-ū,	*a horn.*
Voc.	Don-um,	*O gift.*	Corpŭs,	*O body.*	Anĭmăl,	*O animal.*	Corn-ū,	*O horn.*
Abl.	Don-ō,	*with, from,* or *by a gift.*	Corpŏr-ĕ,	*with a body.*	Anĭmāl-ī,	*with an animal.*	Corn-ū.	*with a horn.*
Plural.								
Nom.	Don-ă,	*gifts.*	Corpŏr-ă	*bodies.*	Anĭmāl-ĭă,	*animals.*	Corn-ŭă,	*horns.*
Gen.	Don-ōrum,	*of gifts.*	Corpŏr-um,	*of bodies.*	Anĭmāl-ĭum,	*of animals.*	Corn-ŭum,	*of horns.*
Dat.	Don-īs,	*to gifts.*	Corpŏr-ĭbŭs,	*to bodies.*	Anĭmāl-ĭbŭs,	*to animals.*	Corn-ĭbŭs,	*to horns.*
Acc.	Don-ă,	*gifts.*	Corpŏr-ă,	*bodies.*	Anĭmāl-ĭă,	*animals.*	Corn-ŭă,	*horns.*
Voc.	Don-ă,	*O gifts.*	Corpŏr-ă,	*O bodies.*	Anĭmāl-ĭă,	*O animals.*	Corn-ŭă,	*O horns.*
Abl.	Don-īs,	*with, from,* or *by gifts.*	Corpŏr-ĭbŭs,	*with bodies.*	Anĭmāl-ĭbŭs,	*with animals.*	Corn-ĭbŭs,	*with horns.*

(1) Decline the following Regular Nouns like *Rosa*:—

m.	Advĕn-a, æ,	*a stranger.*	*f.*	Făb-a, æ,	*a bean.*
m.	Aurig-a, æ,	*a driver* (coach).	*f.*	Găle-a, æ,	*a helmet.*
m.	Naut-a, æ,	*a mariner, a pilot, a sailor.*	*f.*	Hōr-a, æ,	*an hour.*
m.	Poēt-a, æ,	*a poet.*	*f.*	Insŭl-a, æ,	*an island.*
m.	Scrīb-a, æ,	*a writer*	*f.*	Jānu-a, æ,	*a door.*
f.	Al-a, æ,	*a wing.*	*f.*	Mens-a, æ,	*a table.*
f.	Aqu-a, æ,	*water.*	*f.*	Norm-a, æ,	*a rule.*
f.	Ar-a, æ,	*an altar.*	*f.*	Penn-a, æ,	*a pen.*
f.	Arc-a, æ,	*a chest.*	*f.*	Rēgīn-a, æ,	*a queen.*
f.	Cas-a, æ,	*a cottage.*	*f.*	Rīp-a, æ,	*a bank* (river).
f.	Caus-a, æ,	*a cause.*	*f.*	Turb-a, æ,	*a crowd.*
f.	Columb-a, æ,	*a dove.*	*f.*	Und-a, æ,	*a wave.*
f.	Epistol-a, æ,	*a letter.*	*f.*	Vi-a, æ,	*a way, a road.*
			f.	Virg-a, æ,	*a rod, a wand.*

(2) Decline the following Regular Nouns like *Servus*:—

m.	Amic-us, i,	*a friend.*	*m.*	Flŭvi-us, i,	*a river.*
m.	Ann-us, i,	*a year.*	*m.*	Glădi-us, i,	*a sword.*
m.	Căd-us, i,	*a cask.*	*m.*	Hort-us, i,	*a garden.*
m.	Cerv-us, i,	*a stag.*	*m.*	Lŭp-us, i,	*a wolf.*
m.	Corv-us, i,	*a raven.*	*m.*	Mĕdĭc-us, i,	*a physician.*
m.	Dĭgĭt-us, i,	*a finger.*	*m.*	Mūr-us, i,	*a wall.*
m.	Discipŭl-us, i,	*a disciple.*	*m.*	Nīd-us, i,	*a nest.*
m.	Dŏmĭn-us, i,	*a lord.*	*m.*	Răm-us, i,	*a branch.*
m.	Equ-us, i,	*a horse.*	*f.*	Cupress-us, i,	*a cypress.*

(3) Decline the following Regular Nouns like *Donum, n*:—

Antr-um, i,	*a cave.*	Jūdĭci-um, i,	*a judgment.*
Astr-um, i,	*a star.*	Ov-um, i,	*an egg.*
Bell-um, i,	*a war.*	Pĕrīcŭl-um, i,	*a danger.*
Brachi-um, i,	*an arm.*	Prœli-um, i,	*a combat.*
Concĭli-um, i,	*a council.*	Regn-um, i,	*a kingdom.*
Consĭli-um, i,	*an advice.*	Sax-um, i,	*a stone.*
Exempl-um, i,	*an example.*	Scamn-um, i,	*a bench.*
Fact-um, i,	*a deed.*	Tēl-um, i,	*a dart.*
Fŏli-um, i,	*a leaf.*	Verb-um, i,	*a word.*

(4) Decline the following Regular Nouns like *Sermo*.—

m.	Carb-o, ōnis,	*a coal.*	*m.*	Pāv-o, ōnis,	*a peacock.*
m.	Carc-er, ĕris,	*a prison.*	*m.*	Præd-o, ōnis,	*a robber.*
m.	Cŏl-or, ōris,	*a colour.*	*m.*	Trām-es, ĭtis,	*a path.*
m.	Cons-ul, ŭlis,	*a consul.*	*f.*	Æt-as, ātis,	*age.*
m.	Frat-er, ris,	*a brother.*	*f.*	Æst-as, ātis,	*the summer.*
m.	Hŏm-o, ĭnis,	*a man.*	*f.*	Arb-or, ŏris,	*a tree.*
m.	Hosp-es, ĭtis,	*a guest.*	*f.*	Arund-o, ĭnis,	*a reed.*
m.	Lăp-is, ĭdis,	*a stone.*	*f.*	Imāg-o, ĭnis,	*an image.*
m.	Le-o, ōnis,	*a lion.*	*f.*	Mat-er, ris,	*a mother.*
m.	Līm-es, ĭtis,	*a limit.*	*f.*	Regi-o, ōnis,	*a country.*
m.	Mīl-es, ĭtis,	*a soldier.*	*f.*	Virtu-s, tis,	*virtue.*
m.	Past-or, ōris,	*a shepherd.*	*c.*	Cŏm-es, ĭtis,	*a companion.*
m.	Pat-er, ris,	*a father.*	*c.*	Her-ēs, ēdis,	*an heir.*

(5) Decline the following Regular Nouns like *Corpus, n*:—

Căp-ut, ĭtis,	*a head.*	Mūn-us, ĕris,	*a gift.*
Crīm-en, ĭnis,	*a crime.*	Nĕm-us, ŏris,	*a grove.*
Fulm-en, ĭnis,	*a flash of lightning.*	Nōm-en, ĭnis,	*a name.*
Gĕn-us, ĕris,	*a kind.*	On-us, ĕris,	*a burden.*
It-er, ĭnĕris,	*a journey.*	Op-us, ĕris,	*a labour.*
Lit-us, ŏris,	*a coast.*	Pect-us, ŏris,	*the breast.*
Lūm-en, ĭnis,	*a light.*	Pign-us, ŏris,	*a pledge.*
		Vuln-us, ĕris,	*a wound.*

(6) Decline the following Regular Nouns like *Fluctus*:—

m.	Cant-us, us,	*a song.*	*m.*	Nūt-us, us,	*a nod.*
m.	Cās-us, us,	*a fall.*	*m.*	Pass-us, us,	*a pace.*
m.	Curr-us, us,	*a chariot.*	*m.*	Rit-us, us,	*a ceremony.*
m.	Exercĭt-us, us,	*an army.*	*m.*	Sens-us, us,	*a sense.*
m.	Fruct-us, us,	*a fruit.*	*m.*	Sĭt-us, us,	*a site.*
m.	Grăd-us, us,	*a step.*	*m.*	Strĕpĭt-us, us,	*a noise*
m.	Ict-us, us,	*a blow.*	*f.*	Man-us, us,	*a hand.*

(7) Decline the following Regular Nouns like *Cornu, n*:—

Gĕn-u, us,	*a knee.*	Tŏnĭtr-u, us,	*thunder.*

(8) Decline the following Regular Nouns like *Dies*:—

f.	Aci-es, ei,	*the edge.*	*f.*	Spĕci-es, ei,	*an appearance.*
f.	R-es, ei,	*a thing.*			

REFERENCE TABLE OF NOUNS OF THE THIRD DECLENSION.

The nominative of the Third Declension ends in *a, e, o, c, l, n, r, s, t, x*. The genitive is formed from the nominative in the different ways indicated below, but always ends in *is*.

As the Third Declension contains a large number of terminations, and consequently takes a great variety of forms of declension, it is advisable to place before the student a carefully arranged and complete list of all the terminations of its nouns, with the form they take in the genitive, and follow of course in all the cases formed from it.

Nom. ending. — Formation of the Genitive.

A—Gen. adds *tis;* as, pŏēmă, pŏēmă-tĭs, Neut.
E—Gen. *is;* as, măr-ĕ, măr-ĭs, N.
O—Gen. adds *nis;* as, lĕō, lĕō-nĭs; nātĭō, nātĭō-nĭs. But cărō, cărnĭs, M. F.
" (dō, gō)—Gen. *inis;* as, ōrd-ō, ōrd-ĭnĭs; virg-ō, virg-ĭnĭs. So hŏmŏ, nēmō, tūrbō, Apōllō. But lĭgō, lĭgōnĭs, F. M.
C—Gen. adds *tis;* as, lăc, lăc-tĭs, N.
L—Gen. adds *is;* as, sōl, sōl-ĭs. But mĕl, mĕllĭs; fĕl, fĕllĭs, N. M.
N (ān, ēn, ōn)—Gen. adds *is;* as, Tītān, Tītān-ĭs; rēn, rēn-ĭs; sindōn, sindŏn-ĭs, M. F.
" (ĕn)—Gen. *inis;* as, lūm-ĕn, lūm-ĭnĭs, N.
R (ar)—Gen. adds *is;* as, călcăr, călcăr-ĭs; jŭbăr, jŭbăr-ĭs. But fār, fārrĭs, N.
" (er)—Gen. adds *is;* as, cărcĕr, cărcĕr-ĭs; vēr, vēr-ĭs, M. N.
" (tĕr)—Gen. casts out *e* and adds *is;* as, pătĕr, patr-ĭs. Also imbĕr; and names of months in *er*. But Jūpĭtĕr, Jŏvĭs; ĭtĕr, ĭtĭnĕrĭs; lătĕr, lătĕrĭs, M. F. N.
" (ŏr)—Gen. adds *is;* as, hŏnŏr, hŏnōr-ĭs; ărbŏr, ărbŏr-ĭs. But cŏr, cōrdĭs, M. F. N.
" (ŭr)—Gen. adds *is*, as fūlgŭr, fūlgŭr-ĭs; *ŏris*, as ĕb-ŭr, ĕb-ŏrĭs. But jĕcŭr, jĕcĭnŏrĭs and jĕcŏrĭs, N. M.
S (ās)—Gen. *ātis;* as, æt-ās, æt-ātĭs. But vās, vāsĭs; văs, vădĭs; mās, mărĭs; ās, āssĭs. Greek masculine names in *as* make Gen. *āntis;* feminine, Gen. *ădis*, F. M. N.
" (es)—Parisyllables, Gen. *is;* as, nūb-ēs, nūb-ĭs, F.
" " —Imparisyllables, Gen. *ĭtis*, as mīl-ĕs, mīl-ĭtĭs, M.; *ĕtis*, as sĕg-ĕs, sĕg-ĕtĭs, F. M.; *ētis*, as quī-ēs, quī-ētĭs, F. M.; *idis*, only ōbsĕs, præsĕs, M.; *ēdis*, only pēs, pĕdĭs, with its compounds, M.; *ēdis*, only mērcēs, hærēs, F. M. But Cĕrēs, Cĕrĕrĭs; æs, ærĭs; præs, prædĭs.
" (is)—Parisyllables, Gen. *is;* as, ăvĭs, ăvĭs; āmnĭs, āmnĭs, F. M.
" " —Imparisyllables, Gen. *idis*, as lăp-ĭs, lăp-ĭdĭs, M. F.; *ĕris*, only cĭnĭs and pŭlvĭs, M.; *ītis*, only lĭs, Sāmnĭs, Quĭrĭs, Dĭs, M. F. But sānguĭs, sānguĭnĭs; glĭs, glīrĭs.
" (os)—Gen. *ōtis*, as dōs, dōtĭs, M. F.; *ōris*, as flōs, flōrĭs; ōs, ōrĭs, M. N. But cūstōs, cūstōdĭs; bōs, bŏvĭs; ŏs, ŏssĭs.
" (ūs)—Gen. *ūtis*, as virt-ūs, virt-ūtĭs, F.; *ūdis*, as păl-ūs, păl-ūdĭs, but pĕc-ūs, pĕc-ŭdĭs, F.; *ūris*, as tēllūs; and monosyllables, as rūs, mūs, N. M. F. But grūs, grŭĭs; sūs, sŭĭs.
" (ŭs)—Gen. *ĕris*, as vūln-ŭs, vūln-ĕrĭs, N.; *ŏris*, as tēmp-ŭs, tēmp-ŏrĭs; pĕc-ŭs, pĕc-ŏrĭs, N.
" (aūs)—Gen. *aūdis;* only laūs, laūdĭs; fraūs, fraūdĭs, F.
" (ns, rs)—Gen. *tis* for *s;* as, frōns, frōntĭs; pārs, pārtĭs. But frōns, frōndĭs; glāns, glāndĭs, F. M.
" (bs, ps, ms)—Gen. inserts *i* before *s;* as, trābs, trăbĭs; stīrps, stīrpĭs; hȳĕms, hȳĕmĭs. But cælebs, cælĭbĭs; prīncĕps, prīncĭpĭs, F. M.
T (ŭt)—Gen. *ĭtis;* only căp-ŭt, căp-ĭtĭs, and its compounds, N.
X (ăx)—Gen. *ācis;* as, pāx, pācĭs. But făx, făcĭs, F.
" (ēx)—Gen. *icis*, as jūd-ēx, jūd-ĭcĭs; but vībēx, vībīcĭs; vērvēx, vērvēcĭs; nēx, nĕcĭs, M. F.; *ĕgis*, as lēx, lēgĭs; but grēx, grĕgĭs; rēmēx, rēmĭgĭs, M. F. Remark sĕnēx, sĕnĭs; sŭpēllēx, sŭpēllēctĭlĭs.
" (īx)—Gen. *icis*, as cōrn-īx, cōrn-īcĭs, F.; *ĭcis*, as căl-īx, căl-ĭcĭs. But strīx, strīgĭs; nīx, nĭvĭs, M. F.
" (ōx)—Gen. *ōcis;* as, vōx, vōcĭs. But nōx, nōctĭs, F.
" (ūx)—Gen. *ūcis;* as, nūx, nŭcĭs. But lūx, lūcĭs; cōnjŭx, cōnjŭgĭs, F. M.
" (ȳx)—Gen. *ȳgis;* as, Phrȳx, Phrȳgĭs. Some have *ȳcis, ȳcis*, F. M.
" (nx, rx)—Gen. *cis* or *gis;* as, lȳnx, lȳncĭs; ărx, ărcĭs; Sphīnx, Sphīngĭs, F.

Parisyllable is a noun having as many syllables in the Gen. Sing. as in the Nom. Imparisyllable, a noun having more syllables in the Gen. Sing. than in the Nom.

EXAMPLES OF THE DECLENSION OF IRREGULAR NOUNS.

Irregular Nouns are those which do not, in their declension, follow the general rules.

(*a*) IN THE FIRST DECLENSION.

1. *Dea*, a goddess, *filia* and *nāta*, a daughter, and a few others, have *abus* in the dative and ablative plural, as *deabus, filiabus*.

2. Some *masculine* nouns take *um*, by syncope, for *arum* in the genitive plural, as *cœlicŏlum*, for *cœlicolarum*.

3. The following nouns have double forms: (*a*) in the first declension and feminine, (*b*) in the second declension and masculine:—

Agn-a, us,	*lamb.*	Equ-a, us,	*horse.*
Amīc-a, us,	*friend.*	Fīli-a, us,	*child.*
Anĭma,	*the breath of life.*	Lŭp-a, us,	*wolf.*
Anĭmus,	*the human soul.*	Mărīt-a, us,	*spouse.**
Asell-a, us,	*a small ass.*	Nāt-a, us,	*child.*
Asĭn-a, us,	*ass.*	Nunci-a, us,	*messenger.*
Cerv-a, us,	*stag.*	Serv-a, us,	*slave.*
De-a, us,	*god.*	Măgist-ra, er,	*mistress, master.*
Dīv-a, us,	*god.*	Mĭnist-ra, er,	*servant.*
Dŏmĭn-a, us,	*lady, lord.*		

* *Mărītus* is generally used for *a husband*, and *ŭxor* (*ŭxōris*) for *wife; conjux* (*conjugis*) is a less homely and more elegant term for either *husband* or *wife*. *Mărīta* signifies "a married woman." In colloquial usage, as well as in poetry, *vir* is employed for *husband* and *mŭlier* for *wife*.

(*b*) IN THE SECOND DECLENSION.

(1) Some nouns change their gender in the plural—*e. g.*, *cœlum*, n., heaven, plur. *cœli*, m., the heavens; *lŏcus*, m., a place, plur. *loci* (librorum) m., *loca* (terrarum), n.; *jŏcus*, m. a jest or a joke, plur. *joci*, m., *joca*, n.

(2) Some *masculine* nouns have the vocative singular like the nominative.

Examples.

	Singular.		*Singular.*
Nom.	Puer, *a boy.*	*Nom.*	Liber *a book*
Gen.	Puer-i.	*Gen.*	Libr-i.
Dat.	Puer-o.	*Dat.*	Libr-o.
Acc.	Puer-um.	*Acc.*	Libr-um.
Voc.	Puer.	*Voc.*	Liber.
Abl.	Puer-o.	*Abl.*	Libr-o.

The plural, *Puĕr-i, Libr-i*, is declined like *Serv-i* (p. 40).

Decline like *Puer*.

Gĕnĕr, i,	*a son-in-law.*	Sŏcĕr, i,	*a father-in-law.*
Vesper, i,	*the evening.*	Vir, i,	*a man.*

And compounds of *fer* and *ger*, as *signifer* and *armiger*.

Decline like *Liber*.

Ag-er, ri,	*a field.*	Cŏlŭb-er, ri,	*an adder.*
Ap-er, ri,	*a wild boar.*	Cult-er, ri,	*a knife.*
Arbĭt-er, ri,	*an arbitrator.*	Făb-er, ri,	*an artificer.*
Căp-er, ri,	*a he-goat.*	Măgist-er, ri,	*a master.*

(3) *Fīlius*, a son; *gĕnius*, a genius; and proper nouns in *ius*, as *Antonius*, Anthony; *Georgius*, George; *Pompeius*, Pompey, form their vocative by dropping *us:* voc. *fili, geni, Antoni, Georgi, Pompei*.

(4) *Deus*, God, has *Deus* in the vocative. For the pagan gods the plural was as follows:—

Nom. and Voc., *dii;* Gen., *deorum;* Dat. and Abl., *diis;* Acc. *deos*.

(5) There are three neuter nouns in *us: pĕlăg-us, i*, the sea; *vīr-us, i*, poison; *vulg-us, i*, the common people. The accusative and vocative are like the nominative; they have no plural.

(6) Some nouns, by syncope, take *um* for *orum* in the genitive plural, as *nummum* for *nummorum*.

(*c*) IN THE THIRD DECLENSION.

I. Some nouns have the genitive plural in *ium*.

A.—Nouns in *is*, whose genitive singular is like the nominative; as,

f. Av-is, is,	*a bird.*	*f.* Mess-is, is,	*a harvest.*
f. Class-is, is,	*a fleet.*	*f.* Nāv-is, is,	*a ship.*
m. Host-is, is,	*an enemy.*	*m.* Pisc-is, is,	*a fish.*
m. Ign-is, is,	*the fire.*	*f.* Vīt-is, is,	*a vine.*

Gen. plur., *av-ium, class-ium, host-ium, ign-ium*, &c.

Except f. *Ap-is, is,* a bee; m. *Căn-is, is,* a dog; m. *Pān-is, is,* bread; f. *Vŏlŭcr-is, is,* a bird; m. *Jŭvĕn-is, is,* a young man, which have the gen. plur. in *um: ap-um,* &c.

B.—Nouns in *es,* which have in the genitive *is;* as,

f. Clād-es, is, *a defeat.*	*f.* Rūp-es, is, *a rock.*
f. Nūb-es, is, *a cloud.*	*f.* Vulp-es, is, *a fox.*

Gen. plur., *clad-ium, nub-ium, rup-ium, vulp-ium.*

Except f. *Stru-es, is,* a heap; m. *Vāt-es, is,* a soothsayer. Gen. plur., *stru-um, vat-um.*

C.—Nouns in *ns, rs,* and nouns of townsmen in *as,* gen. *atis;* as,

m. Arpīn-as, atis, *an inhabitant of Arpinum.*	*f.* Cŏhor-s, tis, *a cohort.*
	m. Infan-s, tis, *an infant.*
m. Clien-s, tis, *a client.*	*c.* Serpen-s, tis, *a serpent.*

Gen. plur., *Arpinat-ium, client-ium, cohort-ium,* &c.

Except m. f. *Păren-s, tis,* a father or mother, which has *um;* gen. plur. *parent-um.* (*Atrĕbătum, Fīdēnatum, Răvennatum,* &c., are contracted forms.)

D.—*All monosyllables;* as,

m. As, sis, *a pound weight.*	*m.* Mă-s, ris, *a male.*
f. Ar-s, tis, *an art.*	*f.* (Mer-x), cis, *merchandise.*
f. Ar-x, cis, *a castle.*	*m.* Mon-s, tis, *a mountain.*
n. Cŏr, dis, *a heart.*	*f.* Mū-s, ris, *a mouse.*
f. Cō-s, tis, *a whetstone.*	*f.* Ni-x, vis, *the snow.*
f. Cru-x, cis, *a cross.*	*f.* No-x, ctis, *a night.*
m. Den-s, tis, *a tooth.*	*n.* Os, sis, *a bone.*
f. Fal-x, cis, *a sickle.*	*f.* Par-s, tis, *a part.*
f. (Fau-x), cis, *the throat.*	*f.* Stirp-s, is, *the root, stock.*
m. Fon-s, tis, *a fountain.*	*f.* Stri-x, gis, *a screech-owl.*
f. Gen-s, tis, *a nation.*	*f.* Trab-s, is, *a beam.*
m. Glī-s, ris, *a dormouse.*	*f.* Urb-s, is, *a city.*
f. Lī-s, tis, *a lawsuit.*	*m.* Vă-s, dis, *a surety.*

Gen. plur., *ass-ium, art-ium, arc-ium, cord-ium.*

Except n. *Crū-s, ris,* a leg; m. *Du-x, cis,* a general; m. *Flo-s, ris,* a flower; f. *Frau-s, dis,* a fraud; f. *(Fru-x), gis,* fruits; m. *Fūr, is,* thief; m. *Gre-x, gis,* a flock, herd; f. *Grū-s, is,* a crane; f. *Hiem-s, is,* winter; f. *Lau-s, dis,* praise; f. *Le-x, gis,* a law; m. *Mō-s, ris,* a custom; f. *Nu-x, cis,* a nut; m. *Pē-s, dis,* a foot; f. *(Pre-x), cis,* a prayer; m. pl. *Rēn-es, um,* the kidneys; m. *Re-x, gis,* a king; f. *Vo-x, cis,* a voice. Gen. plur., *crur-um, duc-um, flor-um, fraud-um, fur-um,* &c.

E.—Some other nouns; as,

f. Căr-o, nis, *flesh.*	*m.* Quiri-s, tis, *a Roman.*
f. Forna-x, cis, *a furnace.*	*m.* Samni-s, tis, *a Samnite.*
m. Imb-er, ris, *a shower of rain.*	*m. pl.* Optimāt-es, ium *and* um, *men of the highest rank.*
m. Lint-er, ris, *a boat.*	*m. pl.* Pĕnāt-es, ium *and* um, *the household gods.*
m. Ut-er, ris, *a leathern bag or bottle.*	*f.* Pălū-s, dis, *a morass, fen.*

Gen. plur., *carn-ium, imbr-ium,* &c.

II. Many nouns in *is,* gen. *is,* have *im* in the accusative and *i* in the ablative singular; as,

Singular.	*Plural.*
N. Sĕcūr-is, *f., an axe.*	*N.* Secur-es, *axes.*
G. Secur-is.	*G.* Secur-ium.
D. Secur-i.	*D.* Secur-ibus.
Ac. Secur-im.	*Ac.* Secur-es.
V. Secur-is.	*V.* Secur-es.
Ab. Secur-i.	*Ab.* Secur-ibus.

The following nouns are declined like *Securis:*—

f. Amuss-is, is, *a mason's rule.*	*f.* Rest-is, is, *a rope.*
f. Febr-is, is, *a fever.*	*f.* Sĭt-is, is, *thirst.*
f. Pelv-is, is, *a basin.*	*f.* Turr-is, is, *a tower.*
f. Pupp-is, is, *the stern* (ship).	*f.* Tuss-is, is, *a cough.*
f. Rāv-is, is, *hoarseness.*	*f.* V-is, is, *strength(pl.* vīr-ēs).

Names of cities and rivers in *is,* gen. *is;* as, *Hispăl-is, is,* f. Seville; *Tibĕr-is, is,* m. the Tiber; and the Greek nouns in *sis* and *pŏlis;* as, *băs-is, is,* f. a base; *hæres-is, is,* f. heresy; *Neapol-is, is,* f. Naples, have likewise *im* in the accusative, and *i* in the ablative singular.

Most of the substantives in *is,* gen. *is,* which are at the same time adjectives, have *i* in the ablative singular; as,

m. Affīn-is, is, *a relation by marriage.*	*m.* Cănāl-is, is, *a canal.*
	f. Strīgīl-is, is, *a scraper.*
m. Fămīliār-is, is, *an intimate friend.*	*m.* Aprīl-is, is, *April.*
	m. Sextīl-is, is, *August.*

III. Neuter Nouns in *e, al,* and *ar* have *ī* in the ablative singular, *iă* in the nominative, accusative, and vocative plural, and *ium* in the genitive plural; as,

Singular.	*Plural.*
N. Mare, *the sea.*	*N.* Mar-ia, *the seas.*
G. Mar-is.	*G.* Mar-ium.
D. Mar-i.	*D.* Mar-ibus.
Ac. Mare.	*Ac.* Mar-ia.
V. Mare.	*V.* Mar-ia.
Ab. Mar-i.	*Ab.* Mar-ibus.

Decline like *Mare.*

Cŭbīl-e, is, *a couch.*	Vectīgal, is, *a tax.*
Animal, is, *an animal.*	Exemplar, is, *a model.*

Except. The neuter nouns *săl, is,* salt; *făr, ris,* flour; *hēpă-r, tis,* the liver; *jŭbăr, is,* brightness; *nectăr, is,* nectar; and proper names in *e;* as, *Cær-e, is, Prænest-e, is,* are declined in the same way as *corpus* (p. 40). None of these has a plural, except *far,* pl. *farra.*

Bos, gen. *bŏvis,* an ox, has in the Nom. and Acc. plural *boves,* G. *boum,* D. and Ab. *bōbus* or *būbus. Sus,* gen. *suis,* a sow, Gen. Pl. *suum,* D. and Ab. *sŭbus.*

(*d*) FOURTH DECLENSION.

The following nouns have *ŭbus* in the dative and ablative plural.

f. Ac-us, us, *a needle.*	*m.* Part-us, us, *a birth.*
m. Arc-us, us, *a bow.*	*f.* Querc-us, us, *an oak.*
m. pl. Art-us, us, *the limbs.*	*m.* Spĕc-us, us, *a den.*
f. Fīc-us, us, *a fig-tree.*	*f.* Trīb-us, us, *a tribe.*
m. Lăc-us, us, *a lake.*	*n.* Vĕr-u, us, *a spit.*

Port-us, us, m., a harbour, has *ibus* or *ŭbus.*

f. Dŏmus, a house, is partly of the Second and partly of the Fourth Declension. It is thus declined:—

Singular.	*Plural.*
N. Dom-us.	*N.* Dom-us.
G. Dom-us *or* i.	*G.* Dom-uum *or* orum.
D. Dom-ui *or* o.	*D.* Dom-ibus.
Ac. Dom-um.	*Ac.* Dom-us *or* os.
V. Dom-us.	*V.* Dom-us.
Ab. Dom-o.	*Ab.* Dom-ibus.

Note.—The genitive *dom-us* signifies *of a house, of a habitation,* as *fenestræ domus,* the windows of a house; and *dom-i* is only used to signify *at home,* as *sum domi,* I am at home. The dative *domo* is little used.

Jesus, the Saviour, takes *Jesum* in the accusative, and *Jesu* in all the other cases.

(*e*) FIFTH DECLENSION.

The Fifth Declension has no really irregular nouns. The cases in *erum, ebus,* are scarcely ever used except in the nouns *dies, res, species. Dĭēs,* in the singular, is common; in the plural, masculine. *Mĕrīdĭēs,* mid-day, noon, is masculine, and occurs only in the singular.

Several nouns have double forms—one in the First, another in the Fifth Declension:—

Barbăria, Barbăries,	*barbarian.*	Mātĕria, Mātĕries,	*mother-stuff, timber, &c.*
Dūritia, Dūrities,	*hardness.*	Mollĭtia, Mollĭties,	*softness or effeminacy.*
Luxŭria, Luxŭries,	*luxuriance.*		

The foregoing lists of nouns supply an ample vocabulary for the performance of a good many exercises to increase and test the promptness and accuracy of the memory, and the readiness with which the one word suggests the other. The student would do well (1) to commit to memory the examples of the five declensions—Latin and English; (2) to write out in the same form a sufficient number of the nouns given to be

declined in the same way, to insure a thorough acquaintance with the differences of the terminations in the several cases and the meaning attached to each; (3) to decline fully at least three of each of the classes of irregular nouns mentioned as exceptional—paying special attention to the points of difference from the type example pointed out; (4) to copy out in full the special cases of nouns in which any irregularity is mentioned as occurring; (5) to jot down, from memory, now and again, twelve or twenty English words, the Latin equivalents of which appear in the lists, and from memory also supply beneath or opposite to them the Latin terms of similar meaning; (6) to arrange, in a column, twelve or twenty Latin words, and give the English translation opposite; (7) to put on paper as many of the terminal syllables or letters which characterize the several declensions, and under each write down as many nouns, as, without book, he remembers; (8) to arrange the terminations of the several declensions on each side of a small card, then copy or write out from memory, on another card, ten or twelve nouns of each declension, and passing the card with the declension terminations or case endings along each noun on the other card, decline the nouns one after the other; (9) to draw out on a sheet a form containing three columns, headed respectively masculine, feminine, and neuter—each column being separated into two divisions, headed singular and plural; write into each column respectively the nominatives, singular and plural, of as many nouns of each gender as may be remembered; (10) to arrange the names of the cases down the side of a page, then write into the page (arranged in columns) nouns, the example given in each of their cases, in the order of their occurrence. The proper performance of these exercises, all of which can be easily checked off by reference to the contents of this chapter, will insure facility, fulness, and accuracy of knowledge of the declension of substantives.

PHYSIOLOGY.—THE SCIENCE OF LIFE AND HEALTH.

INTRODUCTION.

The object of science is to show the real relations of things one to another. It seeks a knowledge of the order of nature. Lord Bacon has rightly said, "The search for truth, which is the wooing of it; the perception of truth, which is the presence of it; and the belief of truth, which is the enjoying of it, constitute the sovereign good of human nature." This is at once health and wealth—health, because a true life is one spent in accordance with Divine law; and wealth, because such a life is enriched with all the bounties possible to be given to those who fulfil the true conditions of life. Life is, at its lowest, sentient existence, and, at its highest, intelligent—including in intelligence the knowing observance of law, love, truth, and duty. Existence belongs to all phenomenal nature; organized structure is, in this world, the condition of life. In the mysterious circle of the universe, nature seems constantly to aim at renewal. Air, light, heat, and other agencies and elements contain or elaborate the ultimate constituents of the chemical laboratory of creation—oxygen, hydrogen, nitrogen, carbon, &c. These form, in the infinite varieties of their combinations, the inorganic originals of the material world we inhabit. The laws and changes of inorganic matter prepare the nutriment which life seizes, and which it transforms into organic matter. Plants and vegetables possessing life fashion and store the requisites of animal life. Animal life rises from simple sentiency to high sagacity in a multitude of organized structures possessed of individual vitality. At the head of all living existences man stands. He is the highest (known) manifestation of organized matter. He is sensation and thought—a marvellous combination of matter and mind. In him the organic chemistry of vitality acts for a fixed time; then the organic capacities of this frame and its life-forces become exhausted, and the life, which interlinked and wrought within them all, fades, declines, and departs. The organic is disorganized, the living body dies, life vanishes, and so "the old order changeth, giving place to new."

Physiology is, according to its etymology, the science of nature. The nature, however, with which it most concerns itself is human nature, and when used as the designation of a special study—as it is to be here—it is defined as that science which details and explains the normal phenomena of life in human beings, the causes to which they are due, the laws which regulate them, and the consequences towards which they tend. It is here marked off from biology—the science of life—by being confined, in the range of its inquiries, to human life in what it *is* and *does*, and not passing beyond this, except illustratively, to consider the organs and functions of other living structures, whether vegetable or animal. Every living creature may be regarded as (1) a whole, possessed of a specific definite form, which, in the vast majority of cases, is found to be made up of a less or greater number of dissimilar parts, to which the name of *organs* is given; or (2) a whole, endowed with certain commonly manifested powers or capacities, which are designated vital actions, or more definitely *functions*. Biological morphology might be used as the name of the science of organic life, and biological physiology as that of the science of functional life. They are really, however, closely related, for we rarely know fully and truly what an organ *is* till we learn what it *does;* and it is hardly possible, one sees at once, to know rightly what an organ does till we learn assuredly not only that it is but what it is. The apparatus or instrument by which an action is performed is termed an *organ*, and the normal action of an organ—that which it was formed to do—is called its *function*. The active normal performance of each intended function is healthy life.

Physiology assumes that "the proper study of mankind is man." Because self-preservation is a law of nature, it supplies instruction concerning the best methods of preserving this bodily self in healthy vital activity; and because man is a being on whom duties are laid and responsibilities rest, it furnishes information regarding the best means of keeping all the different parts of and agents in the body in their highest and best state of efficiency, so that they may properly perform the constantly recurring succession of phenomena by which man's life is manifested—sensation, action, thought.

Man, as a vital machine, is composed of organized matter. Organized beings are in a constant state of motion and mutation. Combination, transformation, and decomposition—tear and wear, preparation, waste and reparation—go on in a perpetual round throughout the cycle of man's years. Life is a closely-linked, continuous series of changes. This process, which characterizes all life, is called *growth*. Extraneous matter is taken into the body, is therein converted into living tissue—the true and proper substance of the human being into which it is put—and passes thence, when its work is done and its power expended, in various forms into the great storehouse of the elements. Organized creatures grow from a germ, a mere atom, originating in a parent-form, then separated from it, and capable (*a*) of possessing an independent being, and, like its predecessor, (*b*) of producing the life-germ of similar offspring. A plant comprises and completes its life in a series of vital actions having a twofold object—(1) the growth and maintenance of the individual; and (2) the production of successors. An animal adds to this organic existence, sensation and voluntary motion. Its life is more intense; feeling and action—often undertaken for the gratification of feeling—mark it; and hence it is denominated animated existence. To combine animated growth with sensational animation and intellectual perception and activity was requisite in the production of a richly-endowed being like man—a being which could be brought into sensible relation with the external world, social relation with others of similar kind, and intellectual relation with the past, consciousness of the present, and provident forthlook for the future.

The double life of growth and consciousness necessitates a double yet aptly-fitted apparatus for carrying on the processes of the vital economy. These are (1) the apparatus of the *organic* life, by which individual existence is maintained, the action of which must be constant, and may not be intermitted or suspended: these, such as the heart, the stomach, the liver, &c., are single; and (2) the organs of *animal* life, the means by which the living being is brought into relation to the external world, and the joy and duty made possible by that relation: these are symmetrical and double. The lungs

occupy a place on either side of the interior of the chest; the brain and the spinal cord are divided into two equal parts; the nerves, which pass off and go out from them, do so in pairs similar in kind and distribution; the muscles of the one side of the body have their counterparts on the other; the extremities on either side are as like as may be. In point of fact, a line passing through the centre of the frame would separate the animal as distinguished from the vegetative organs into two essentially equal and similar divisions. As human health depends upon the safe, continuous, and regular action of the functions of organic life, the organs of these functions are all carefully placed and packed in the safest possible positions in the interior of the frame, and well protected from the action of external objects upon them to their injury. Again, as the happiness of human life results from the readiness, fulness, and freedom of its relations with nature and the creatures who dwell in the external world, the organs of sense, the ministrants to intelligence and the instruments of action, are placed where they can be of the greatest service. It is necessary for the fulfilment of their functions that they should be situated and arranged on the exterior of the body; and so they are. The more important apparatus of the vital structures is supported and defended by a bony framework—a movable trunk, in the interior of which the organic functions are safely performed—while the locomotive powers and agents enable the living organism to seek the means of living; appropriate and use the materials of nature to its wants and purposes; and fetch and carry movable things to itself, itself to immovable things. The senses, as agents of pleasure and instruments of intelligence, are near the brain-reservoir of perception and will, and occupy every "coigne of vantage" for observation and the exercise of a vigilant sentinelship. The nerves, under the charge of the brain and the spinal cord, stimulate the muscles; they operate, through appropriate tendons, on the bones; and the entire vital economy, when in a healthy condition, works without consciousness. Consciousness is the characteristic of vital, not of organic function. Health is unconscious of itself. Disease is the consciousness of disorganization or injury.

There is no subject in which the people are, and ought to be, so deeply interested as the structure and functions of their own bodies. And yet a general and deplorable ignorance prevails upon it. That we are "fearfully and wonderfully made" constitutes with many the sum and substance of their knowledge of themselves as animal existences and living creatures. The structure and functions of the human body can only be wisely and profitably pursued by commencing at the beginning and proceeding through a regular series of well-arranged and properly graduated instructions, with diligence and attention, to their designed termination. In that way alone can we learn to comprehend ourselves; and, after minute investigation, to which this will lead us, and the array of facts and reasonings with which it will furnish us, the skilful arrangement, symmetry, uses, and beauty of the animal machine will be rationally perceived and intelligently appreciated. We admire the steam-engine—it is worthy of admiration—it is one of the greatest and most useful inventions of man; but *man* is a machine which, for mechanical arrangement and accurate adaptation, as far surpasses *it* as a natural plant excels an artificial flower. There is nothing like *man* in organic nature. He bears *upon him* and *within him* the impress of his almighty Creator. From conception till death the body is endowed with a mysterious vitality; and when our mortal destiny is finished life vanishes, and our bodies resolve into the elements that composed them. This is the law of organic nature—inexplicable, immutable, irreversible; and there is no exemption from its discharge.

The human body is composed of parts; each part constitutes a separate economy depending on the whole, and the whole is sustained by its parts. Internally there is a strong framework of bones, and on these the superstructure is built; over the bones is laid a thick bed of muscle or "flesh," in regular thin layers, composed of long slender fibres, each layer acting like a pulley, raising and depressing the bones at the will of the individual. To the extremity of each of the deep-seated muscles (over the bones), a piece of strong white tendinous cord is attached, and inserted into the bone, by which it is moved; and thus motion and locomotion are performed. The joints are mechanically constructed, nicely adapted to each other, the bones being attached by ligaments that bind them together and—unless under unusual circumstances—prevent dislocation. In the bones, the muscular fibres, and each part of the body, blood-vessels, composed of arteries and veins, ramify in every direction, from the thickness of a child's wrist to that of an almost imperceptible thread. The arteries convey the oxygenated blood to every part of the body, to repair its waste and nourish its growth. The veins return the blood carbonized, and therefore unfit for nutrition, to the heart, to be re-oxygenated, by the inhalation of atmospheric air, in the lungs, and to be, by expiration, deprived of the carbon that would render it injurious or destructive to animal life.

In the abdominal cavity or belly we have the stomach, bowels, liver, spleen, pancreas, and kidneys, each and all performing their separate work in silence, order, and harmony. The stomach receives the masticated food, and, by its gastric juice, digests it. The liver pours its bile into the duodenum (or first part of the small intestine), assists digestion, separates the nutritious from the innutritious aliment, and aids the expulsion of the latter. In the upper region of the bowels, the lacteals—those little absorbent vessels which resemble in their office the rootlets of plants—suck up the nourishing part of the food, and send it, by the mesenteric glands, into the receptacle of the chyle; it passes thence (in a milky fluid) into the chyle-duct, and, contrary to the laws of gravity, ascends from the abdomen until, beneath the left shoulder, it is emptied into the left subclavian vein, and mingles with the blood.

In the thorax or cavity of the chest we have the lungs, composed of delicate cells and blood-vessels, receiving and expelling the respired air. The circulating fluid passes from the heart into the lungs, and is there exposed to the action of the air we breathe. There it parts with the carbonic acid, watery vapour, &c., which it had imbibed in the course of its circulation, and absorbs oxygen. By this means it changes from a dark purple to a bright scarlet-red. It then returns to the heart, and is sent, by the simultaneous action of the arteries, into every part of the body, to nourish and repair it. This extraordinary process never ceases till we die, although it operates entirely without our consciousness and will.

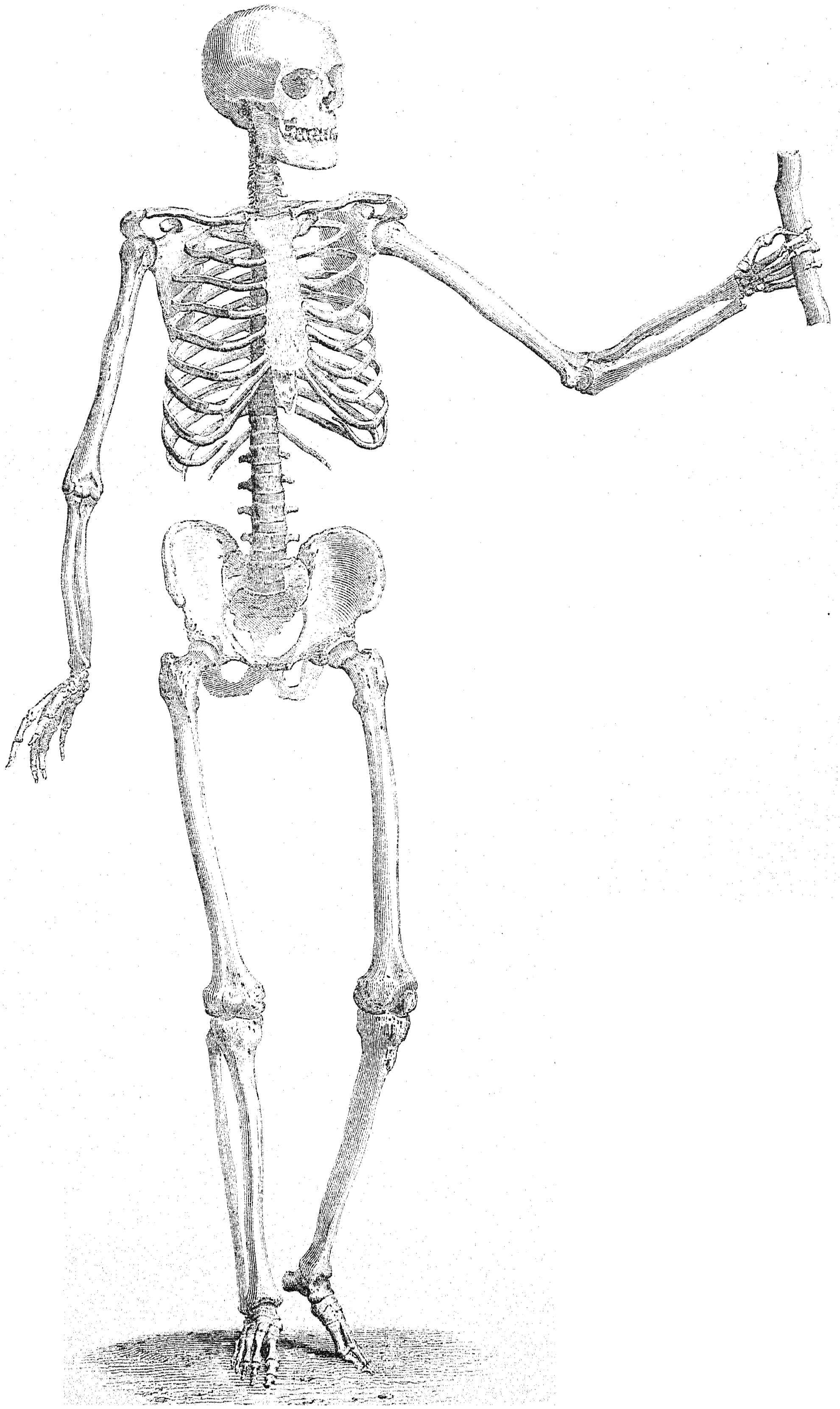
In the hollow bone-case—the skull—we have the brain, the most mysterious organ in nature. It is divided into two hemispheres and several lobes. It is inclosed in three membranes. We have two distinct brains—the *cerebrum* before, and the *cerebellum* behind. The spinal cord is a prolongation of the brain, inclosed in a solid jointed column of carefully articulated bones, with a sort of tunnelled canal bored through each, yet all nicely joined together by intermediate cartilages that render it flexible, and, by the nicest mechanism, prevent spinal compression. From the brain and the spinal cord—the latter of which extends longitudinally through the vertebral canal—numerous nerves extend in every direction, from the thickness of the little finger to the finest gossamer-thread, giving life, sensation, and motion to every part of the body. The brain seems to be an apparatus in which the vital principle is generated, and the nerves are vital conductors. The nerves of the senses communicate between the mind and the external world through the medium of the brain. The spinal cord derives its function directly from the brain, and gives motion and sensation (by two sets of nerves) to the parts supplied. The heart and arteries pulsate by nervous power received from the brain, and are stimulated by the circulating blood. We move our bodies by nervous energy derived from the spinal cord and the brain. We see, hear, taste, feel, smell, eat, drink, digest, grow, and renew by nervous influence that has its origin in the brain. The mind resides in the brain; we cannot live, think, reason, judge, nor do anything vital and rational without the brain; it is the material organ of the mind, by which she communicates with the external world.

To make the animal machine a little world, individualized and perfect, the external skin is so deftly wrought around it that it completely envelops and preserves the body, and defines the outward form to the observer's eye and our own feeling.

The animal machine is self-preserving and self-propagating.

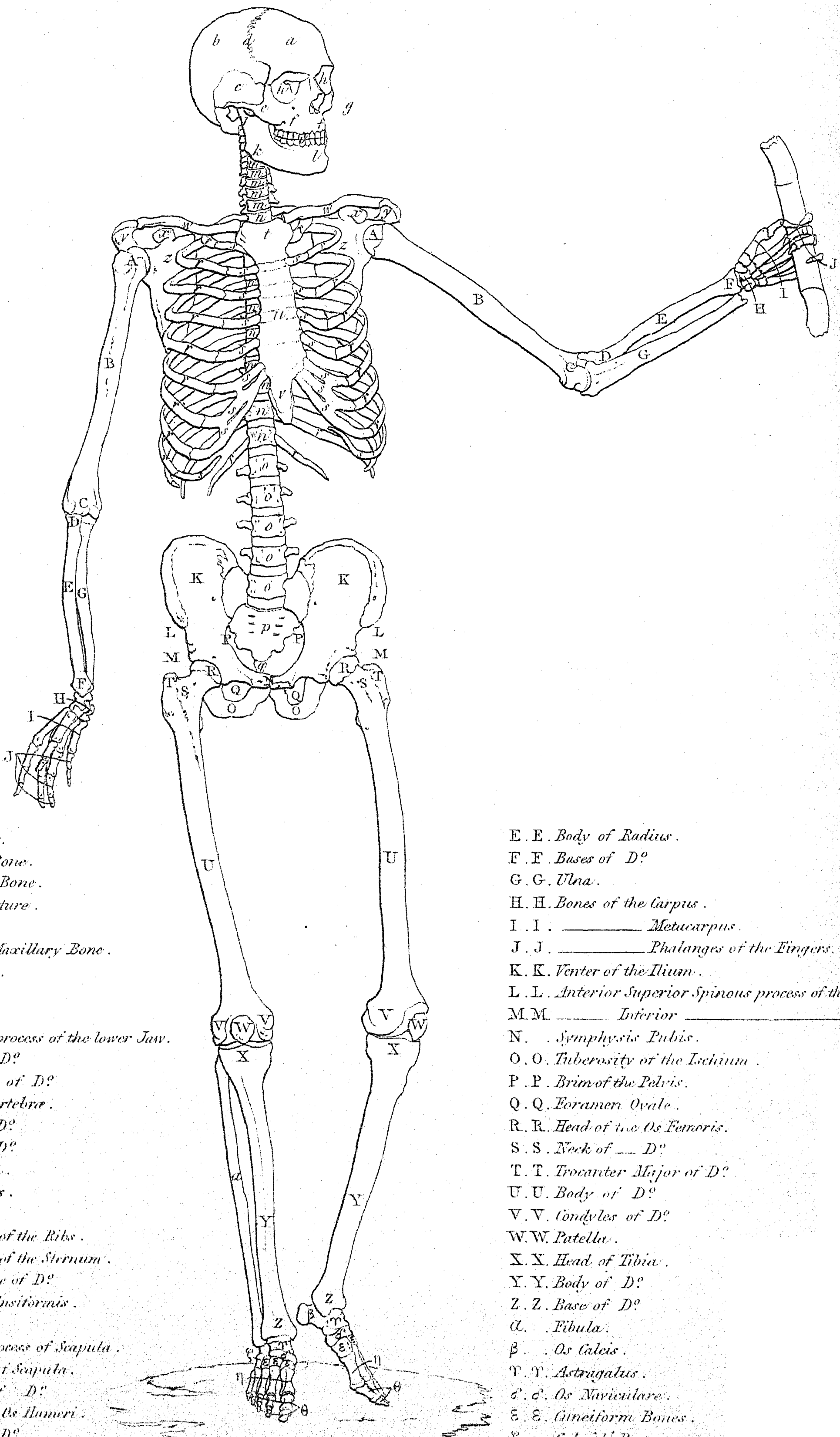
Plate I.

FRONT VIEW OF THE MALE SKELETON.



PHYSIOLOGY.

REFERENCE TO THE FRONT VIEW OF THE MALE SKELETON.



a. . *Os Frontis.*
b. . *Parietal Bone.*
c. . *Temporal Bone.*
d. . *Coronal Suture.*
e. . *Os Malæ.*
f. f. *Superior Maxillary Bone.*
g. g. *Ossa Nasi.*
h. h. *Orbits.*
i. . *Teeth.*
j. . *Condyloid process of the lower Jaw.*
k. . *Angle of D°.*
l. . *Symphysis of D°.*
m. m. *Cervical Vertebræ.*
n. n. *Dorsal — D°.*
o. o. *Lumbar — D°.*
p. . *Os Sacrum.*
q. . *Os Coccygis.*
r. r. *Ribs.*
s. s. *Cartilages of the Ribs.*
t. . *First bone of the Sternum.*
u. . *Second bone of D°.*
v. . *Cartilago Ensiformis.*
w. w. *Clavicles.*
x. x. *Coracoid process of Scapula.*
y. y. *Acromion of Scapula.*
z. z. *Venter of D°.*
A. A. *Head of the Os Humeri.*
B. B. *Body of — D°.*
C. C. *Condyles of D°.*
D. D. *Head of Radius.*

E. E. *Body of Radius.*
F. F. *Bases of D°.*
G. G. *Ulna.*
H. H. *Bones of the Carpus.*
I. I. ——— *Metacarpus.*
J. J. ——— *Phalanges of the Fingers.*
K. K. *Venter of the Ilium.*
L. L. *Anterior Superior Spinous process of the Il*
M. M. ——— *Inferior* ———
N. . *Symphysis Pubis.*
O. O. *Tuberosity of the Ischium.*
P. P. *Brim of the Pelvis.*
Q. Q. *Foramen Ovale.*
R. R. *Head of the Os Femoris.*
S. S. *Neck of — D°.*
T. T. *Trocanter Major of D°.*
U. U. *Body of D°.*
V. V. *Condyles of D°.*
W. W. *Patella.*
X. X. *Head of Tibia.*
Y. Y. *Body of D°.*
Z. Z. *Base of D°.*
α. . *Fibula.*
β. . *Os Calcis.*
γ. γ. *Astragalus.*
δ. δ. *Os Naviculare.*
ε. ε. *Cuneiform Bones.*
ζ. . *Cuboid Bone.*
η. . *Metatarsal Bones.*
θ. . *Phalanges of the Toes.*

The blood circulating in the body deposits the materials it carries in its course in minute quantities wherever they are required, supplies the bodily waste, and repairs its injuries. All the parts of the body are supplied with blood. As we begin to grow old the organs that form the blood become enfeebled, their products deteriorate in quantity and quality, and they are thus rendered unfit for animal nourishment. Hence the progress of decay as we advance in age.

The vital origin of the living body is a germ-cell, little more perhaps than the $\frac{1}{120}$ of an inch. Out of this earliest atom of vitalized matter the whole body is gradually upbuilt and formed. When grown, what does it show us? Only a succinct and plain statement, such as may not exceed the comprehension of the least learned of readers, is all that can be attempted now. Subsequently the details shall be consecutively developed before the mind, and what is known of man as a living machine, seen as it were in the transparency of science, will be exhibited in the course of our future studies.

The body may be superficially thus described:—There is, first, the head, consisting of the facial parts and the skull. The skull, covered with flesh and clothed with hair, rests on the top of the spinal column and encases the brain. Having an opening through the mouth, the throat, on passing down the neck, contains both the windpipe and the gullet, which enter into the great hollow of the chest in the rear of the breastbone. The windpipe terminates in the lung-tissues, into which it leads the breath; the other takes its way, near to the spine, through the partition-wall, called the diaphragm, between the chest and the abdomen to the stomach, of which it is the feeder. The stomach has attached to it the intestines, and has associated with it in the work of elaborating the food, the liver, the spleen, the pancreas, the kidneys, the bladder, &c., which fill up the lower cavity of the frame. From the gullet to the termination of the intestines may be called the alimentary canal. In the upper cavity, besides the lungs, there is the heart, with its great arterial tubes and its return supply of veins—the circulatory and nutritive apparatus. Forming the main-stay of this double-hollowed trunk is the spinal column, with its well-fitting series of jointed vertebræ extending down the centre from the neck to the legs. To the trunk are fastened the arms on either side above, and the legs on each side below, enabling man to stand erect and to be industrious, while they exalt the percipient brain and place in the most advantageous position all the special organs of sensation. Such is a rough outline-sketch of the general topography, if we may so call it, of the body of man.

Notwithstanding the perfection and beauty of this animal machine, there exists in its constitution the mysterious necessity for death. "No sooner has man breathed his last than those mechanical agents, external and constitutional, which, when subservient to life, kept him from decomposing, now usurp the supremacy, and begin to decompose that fabric which formerly they not only had reared but likewise preserved; ammoniacal and inflammable gases evolve before the body be buried." The body rapidly decomposes; for no long time does it resist putrefaction. It soon gets reduced into its simple elements, and—so true is the oldest account we have of human nature, "Dust thou art and unto dust shalt thou return"—it becomes in irregular succession part of other animals, minerals, water, earth, air, and plants. The same elements that compose our bodies may have already passed, and may yet pass, through every variety of combination in nature.

PHYSIOLOGY.—CHAPTER I.

THE STRUCTURE AND USES OF THE SKELETON.

UNDER the somewhat fanciful title of "the house I live in" it has been found possible to suggest a very ingenious analogy to the mind, between the build of a house and the architecture of the human body as the dwelling-place of mind. The idea of construction lends our thoughts something familiar to take with us in our researches into the structure of the living body. We all know how houses are erected and adapted to their purpose, how ships are built and fitted out for differing uses, how machines are constructed and made available for various operations and ends. Man's body is not only a tabernacle of clay, but a locomotive and a machine. It is a vital, moving, and industrial agent, and withal it is a growing or self-building and self-repairing creature. It is regarding the interior build of the body of man we are now about to treat. Man is a complex being; he is a series of systems interwrought into unity. Each of these discharges its own specific set of functions, and yet all work together for the common good of each. The *bones* form the framework, the *joints* provide for its movement, the *muscles* perform its motions, and the *nerves* regulate action and supply intelligence. There is a *digestive system* for preparing aliment, an *absorbent* one for gathering out and collecting the aliment, and a *circulatory* one for carrying the aliment wherever it is needed; and a *defecating* one for cleansing, purifying, and carrying off matter not required. We shall direct our attention first of all to the inner framework of the house of life.

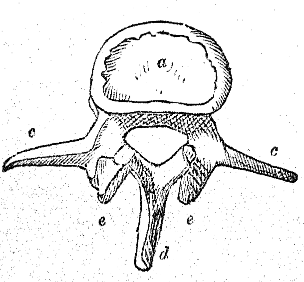
The skeleton (from σκελετος, dried up, parched) is the osseous or bony framework or scaffolding which distinguishes vertebrate from invertebrate animals. The term vertebrate indicates that the animals to which it is applied are provided with vertebræ, or spine bones. These are the primary or essential elements of the skeleton, to which all the other parts are appended as offshoots. The skeleton is the organized bone-structure of an animal which requires for its healthy existence a duly protected vegetative life-system—that is, the hæmal (or blood-forming) organs and the vascular axis—and a carefully inclosed sensitive (cerebro-spinal or neural) system. It involves a dorsal column and its appendages, and is thus distinguished from a-skeletonic or invertebrate animals. Hence the possession or non-possession of a skeleton determines whether an animal shall be classed among the vertebrates or the invertebrates. Every part of the animal body is admirably adapted for the circumstances in which it is to pass its life, and the archetypal skeleton is wonderfully altered to suit the varied requirements of terrestrial, aquatic, and flying animals. The skeleton is composed of a series of vertebræ (segments of bone) arranged in a well-compacted contiguous row. To understand its necessity we must remember (1) that in vertebrate animals we have a sensitive and a nutritive system; and (2) that the important parts which form the seats and instruments of sensation, and are the agents in digestion and circulation, require to be inclosed, protected, supported, and moved. We have therefore the nutrition-inclosing trunk and the nerve-inclosing brain and spinal chord, with the appendages of motion and support, the arms and legs. The trunk requires, in man, to be columnar and erect, but it must not be rigid or immovable. It must combine the straightness of an upright rod that it may stand and support, and the mobility of a chain that it may bend without breaking. From its ideal resemblance to a flexible thorn-stick it has been called the spine or spinal column. According to the special necessity of each animal the skeleton differs less or more from the archetypal or ideal skeleton. Man, as the highest form not only of mammal but of animal, accumulates in his osseous structure the largest number of divergencies from the simple type, and exhibits on the whole the greatest amount of complexity in skeletonic build. Yet there is in all vertebrate animals so great a general resemblance that, allowing for the various adaptations necessary to fit each creature for its own peculiar element and mode of life, the plan of the skeleton may be said practically to be the same. The one ideal pervades, and is perceptible through, each of the real forms in which vertebrate life is manifest.

If we compare the skeleton of an eagle with that of an elephant, we see that although there is a similarity in each individual part, sufficiently obvious to be remarked and so far comprehended even by the most casual observer, yet the general characteristics are as widely different as is the mode of life of one from that of the other. Again, it is very interesting and instructive to take a single organ, as, for instance, the skeleton of the hand, or head, or back, and examine analogous parts in various animals, when we see that, though all constructed on the same type, they are modified to suit the habits of each individual. If anyone

will examine the backbone of a chicken, and compare it with that of a rabbit or a hare, he will see an admirable illustration of what is here alluded to. The chicken has two distinct parts of its skeleton, the neck and the back. In the neck the bones are as loose and as finely articulated as those of a serpent, to afford the free and extensive motion necessary to enable it to pick up the grains of corn from the ground, and to arrange its feathers at any part of its body. The back, on the contrary, is as stiff and unyielding as the shell of a tortoise, in order to afford a fixed point from which the muscles of the wing may act with sufficient power. If the neck were stiff, the bird would die from want of power to pick up grain. If the back were flexible, each attempt to move the wing would twist the body in such a way that the animal would fall helpless to the ground. In the rabbit, however, the flexibility begins with the head and extends all through the back, to enable the animal to make those free and rapid motions by which she eludes her pursuers.

The human skeleton, with which we are here specially concerned, is shown in Plates I., I.A, II., II.A, which give, with a good deal of fulness, also the names of the different bones of which it is composed. It consists of (1) the head, (2) the trunk, and (3) the extremities. 1. No explanation is needed to define the limits of the *head*. It is the upper part of the body in man, all that portion which is placed above the first bone of the neck. 2. The *trunk* is composed of the spine, the ribs, the breastbone, and the pelvis. It supports the head upon its upper end, and rests its lower end on the tops of the thigh-bones. The *extremities* are four—two *superior*, commonly called in man the arms; and two *inferior*, commonly called the legs; but, in strict anatomical language, the word *leg* is applied to the part below the knee, the part above being always spoken of as the *thigh;* and only the part above the elbow is called the *arm*, the part below being the *forearm*. We shall now examine each of these parts in succession more minutely.

The *spine* is the central column (see Plate III., fig. 1). It rests on the pelvis and thigh-bones, and supports the chest, the head, and the superior or upper extremities. It is about one-third of the length of the whole body. It consists of thirty-three pieces, or *vertebræ*, so named from the Latin word *vertere*, to turn, on account of their mobility. The largest is placed below, and they diminish gradually to near the top. Each vertebra is a bone irregular in its structure. It consists of a *body* and *processes*. Process, in anatomy, signifies a projection or prominence. The body of each vertebra is a short bone, spongy in texture, and very light. It is nearly semicircular, convex in front, and flat above and below, where it supports and rests upon its neighbours. In the accompanying cut, and also in Plate III., figs. 2, 3, and 4, *a* represents the body of the vertebra, with its upper flat surface turned toward the reader. From the back of the body the arch of the vertebra is seen to spring, inclosing a space which is occupied by the spinal marrow, *b*.



A couple of articular processes, *e e*, are seen, which receive a corresponding pair from the vertebra above, and two, similar to these, *f f*, are sent downward, to articulate with the one next below. Then, to serve as levers, for the purpose of bending and turning the spine, we have two transverse processes, *c c*, passing out on each side, and the spinous process, *d*, passing backward. These spinous processes form the chain of projections felt under the skin, and give their name to the whole column. The three-and-thirty vertebræ are so joined together as to allow of a little motion, and but a little, at any one joint, in order that the spinal marrow which passes down through the canal formed by the apposition of the different rings may not be injured by too sudden a twist or jolt; but that the curves which it is obliged to form, in the various motions of the body, may be very gradual. The surface of the spinal column which is presented to the front is smooth and rounded; that presented to the back is rough and irregular; and along the middle there spring from it strong, sharp, pointed projections of bone, called spinous processes, from which circumstance the entire columnar chain of the vertebræ receives its name—the spine.

Even when at rest the spine is not straight, but takes a series of curves, as shown in Plate III., fig. 1 B. First, it curves forward, where it rests on the pelvis, that it may not be exposed to too rough a shock, when we begin to move, after being in a state of rest. Secondly, it curves outward, in the region of the back, to increase the capacity of the chest, in which the heart and lungs are lodged. Thirdly, it curves forward again in the neck, to bring the weight of the head, which rests on it, over the point of support between the feet.

Three regions are distinguished in the spine—first, the *cervical* (or that of the neck), consisting of seven vertebræ (shown in fig. 2, Plate III.); second, the *dorsal* (or that of the back), consisting of twelve (shown in fig. 3); and third, the *lumbar* (or that of the loins), consisting of five. They can be easily counted in Plate III., fig. 1. The vertebræ of the loins are the most movable; it is here that the turning and bending of the trunk chiefly takes place, and consequently it is in this region that injuries are most apt to occur. Those of the neck are also very movable, so that they may allow of the head being turned in every direction, principally, it would seem, to extend as much as possible the sphere of vision.

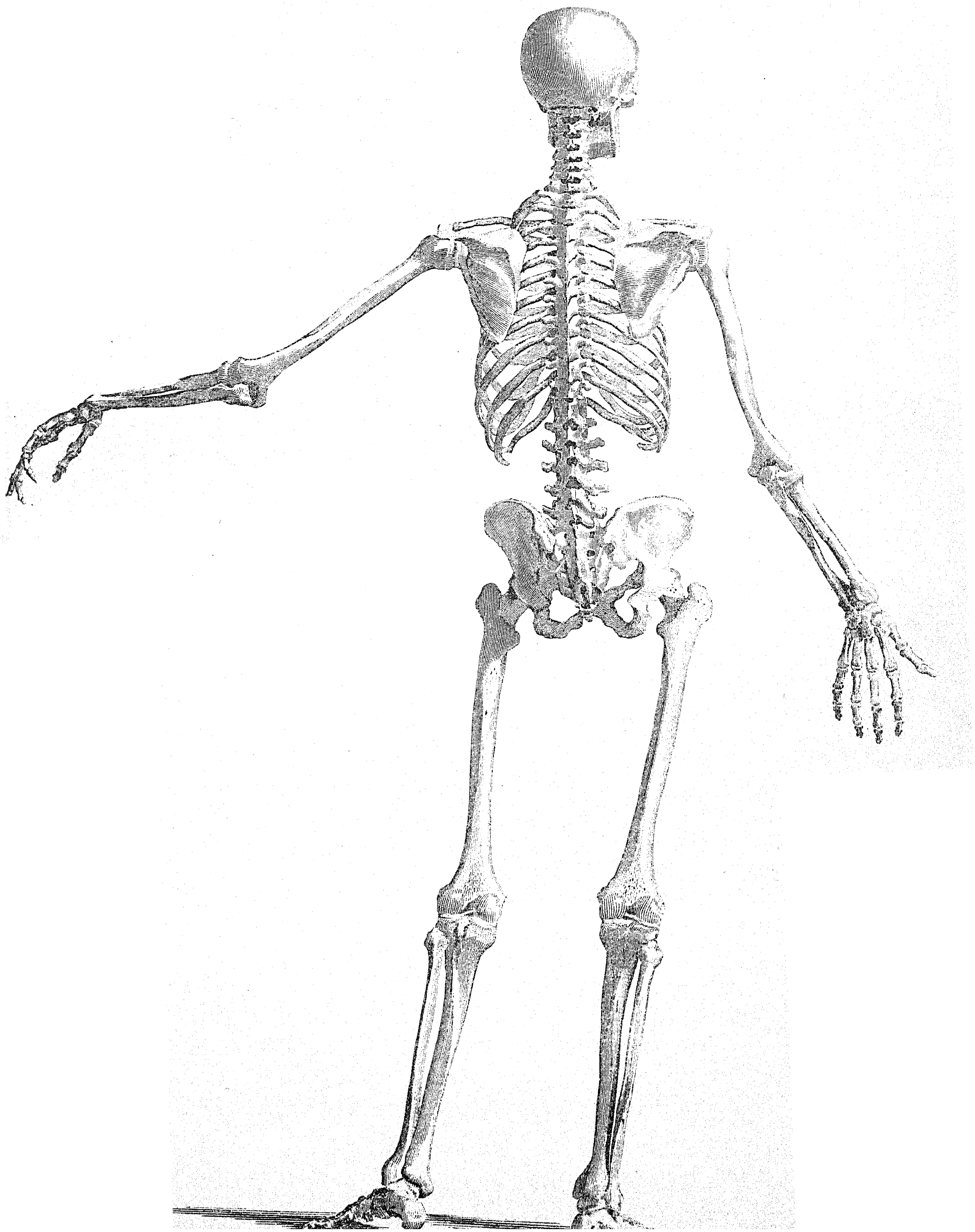
To the twelve dorsal vertebræ the ribs are attached. There are twelve on each side. Taken together they form the chest. On this account, these vertebræ admit of but little motion on one another, because they, with the ribs and breastbone, are meant to work together, as constituting, in a great measure, a single organ.

The *ribs* (see figs. 5 and 6, Plate III.) are long, curved, elastic arches of bone, convex externally and concave internally. They get gradually longer from the first to the seventh, and from that shorter again to the twelfth. The ten upper ribs are joined to the breast-bone in front by thin cartilages, an arrangement which gives elasticity to the walls of the chest. The seven higher ones are more distinctly connected with the breast-bone than the others, and are called *true* ribs. The other five are called *false* ribs, and the lowest two of them, not being attached in front, are called the *floating* ribs. The heads of the ribs behind are connected to the vertebræ by a kind of hinge joint (fig. 7), which allows each rib to move up and down in the action of breathing. Each rib passes from its attachment downward, outward, and forward; so that when lifted up by the muscles of inspiration it at the same time is carried outward, and so enlarges, in both directions, the capacity of the chest. The upper edge of each rib is thick and rounded, while the lower is marked with a deep groove, in which the intercostal nerve and vessels lie. The distances between the ribs are termed the *intercostal spaces*.

The *breast-bone* (*sternum*), shown in fig. 8 in three positions, and in fig. 5 with ribs attached, is about 7 inches long, nearly 2 broad above, and 1 below, and ends in a movable point formed of cartilage. It is smooth and convex in front, gives prominence to the fore-part of the chest, and projects conspicuously in some individuals, who are thence called "pigeon-breasted." The cartilages of the ribs are inserted into its edges (as seen in fig. 9). It has a hollow in its upper part to make room for the windpipe to pass down behind it, and the two collar-bones are attached to its two upper corners. (See *w*, Plate I.A.)

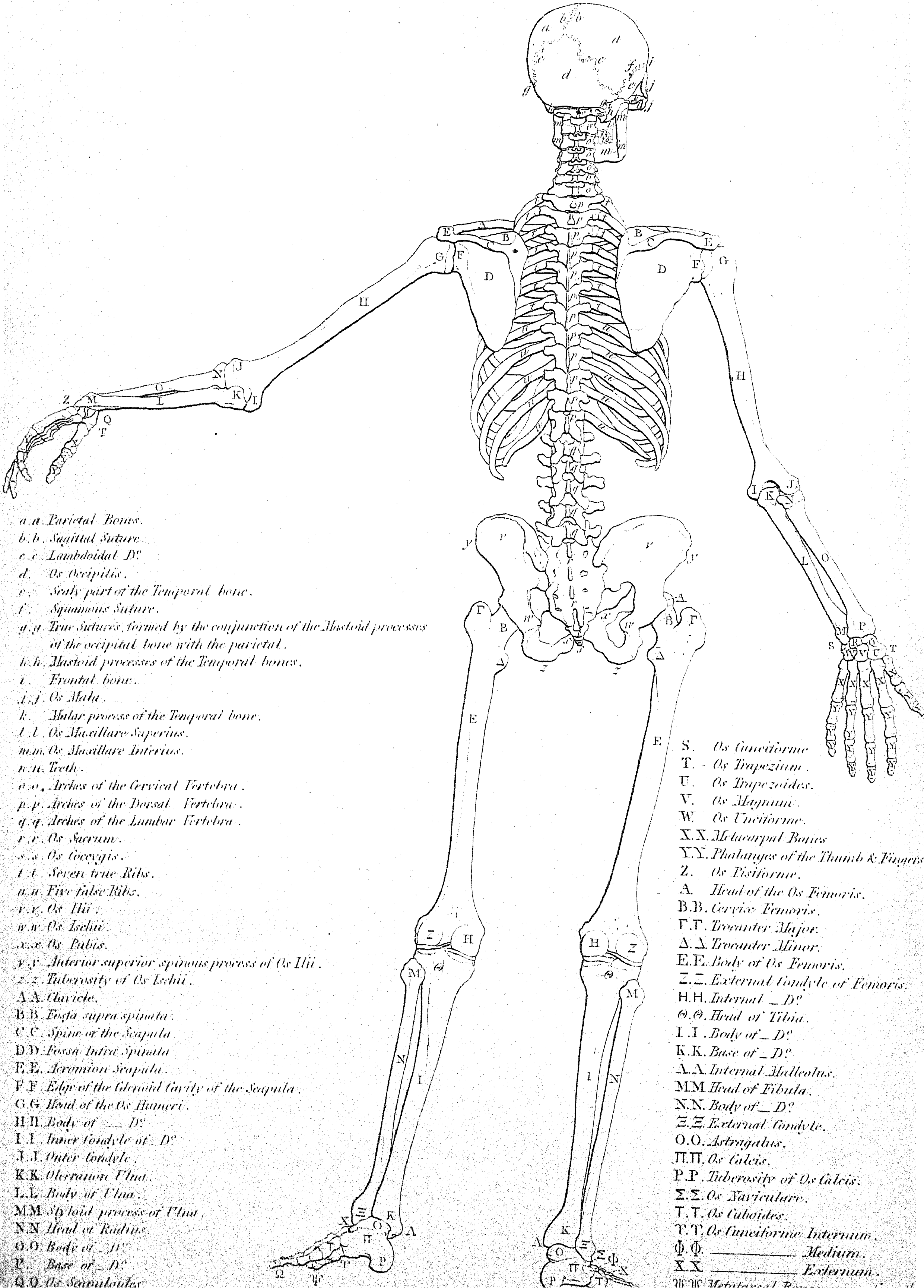
The *chest* or *thorax* is the upper cavity of the trunk, that in which the heart and lungs are packed. It is inclosed by (1) the thoracic portion of the spinal column, extending along twelve of the dorsal vertebræ; (2) twelve ribs on each side, fastened to these; (3) the sternum, which occupies the front; and (4) the diaphragm, a thick muscle which separates the thoracic from the abdominal cavity. It is, when viewed as a whole, conical—the apex of the cone being above, and the base below. The aperture above is small. It measures about 4 inches across, and 2 from front to back, in this space allowing the windpipe and gullet, and the great veins of the

BACK VIEW OF THE MALE SKELETON.



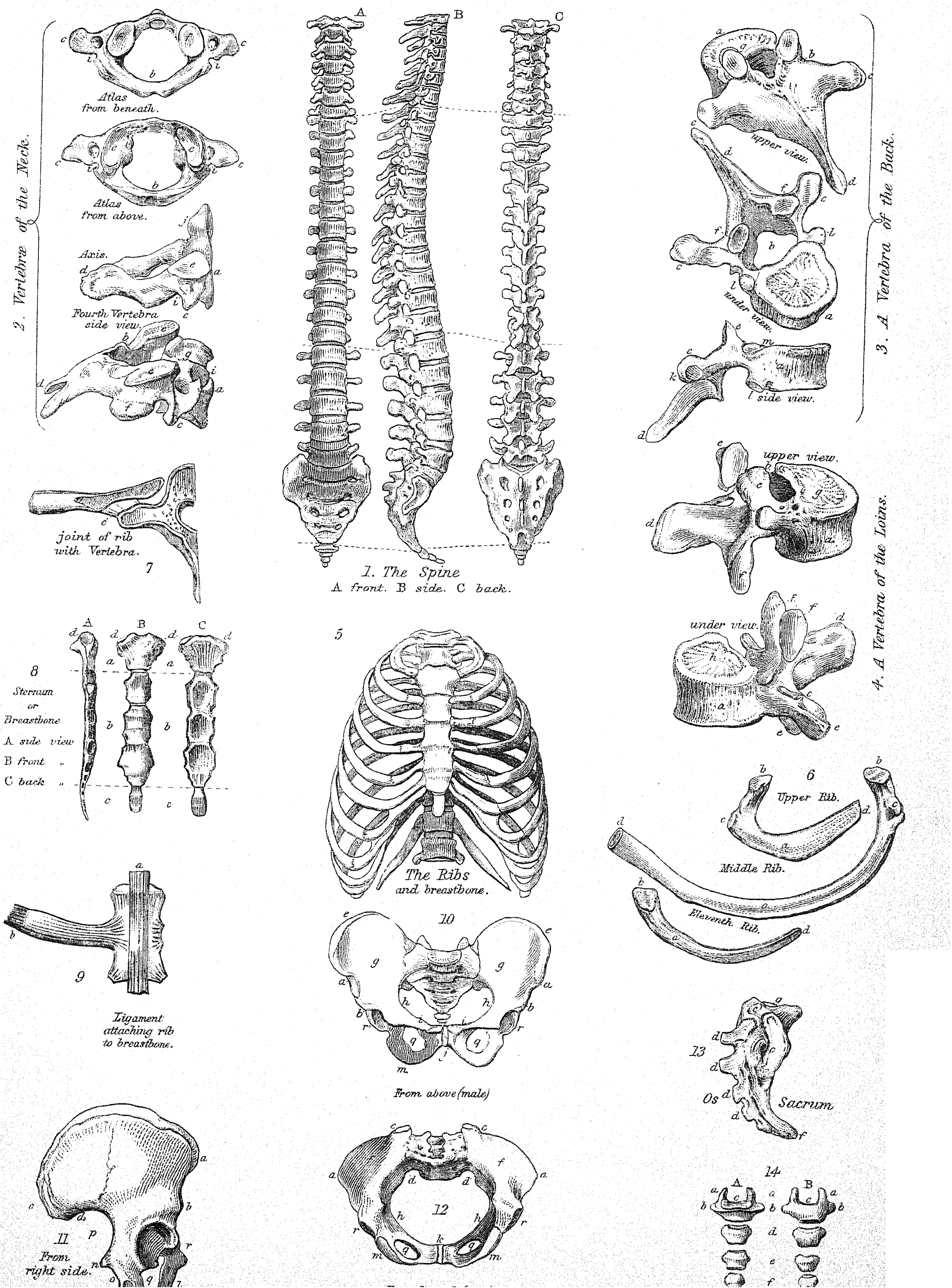
PHYSIOLOGY.

REFERENCE TO THE BACK VIEW OF THE MALE SKELETON.



a.a. Parietal Bones.
b.b. Sagittal Suture.
c.c. Lambdoidal D^o.
d. Os Occipitis.
e. Scaly part of the Temporal bone.
f. Squamous Suture.
g.g. True Sutures, formed by the conjunction of the Mastoid processes of the occipital bone with the parietal.
h.h. Mastoid processes of the Temporal bones.
i. Frontal bone.
j.j. Os Mala.
k. Malar process of the Temporal bone.
l.l. Os Maxillare Superius.
m.m. Os Maxillare Inferius.
n.n. Teeth.
o.o. Arches of the Cervical Vertebra.
p.p. Arches of the Dorsal Vertebra.
q.q. Arches of the Lumbar Vertebra.
r.r. Os Sacrum.
s.s. Os Coccygis.
t.t. Seven true Ribs.
u.u. Five false Ribs.
v.v. Os Ilii.
w.w. Os Ischii.
x.x. Os Pubis.
y.y. Anterior superior spinous process of Os Ilii.
z.z. Tuberosity of Os Ischii.
A.A. Clavicle.
B.B. Fosfa supra spinata.
C.C. Spine of the Scapula.
D.D. Fossa Infra Spinata.
E.E. Acromion Scapula.
F.F. Edge of the Glenoid Cavity of the Scapula.
G.G. Head of the Os Humeri.
H.H. Body of __ D^o.
I.I. Inner Condyle of D^o.
J.J. Outer Condyle.
K.K. Olecranon Ulna.
L.L. Body of Ulna.
M.M. Styloid process of Ulna.
N.N. Head of Radius.
O.O. Body of _ D^o.
P. Base of _ D^o.
Q.Q. Os Scaphoides.

S. Os Cuneiforme.
T. Os Trapezium.
U. Os Trapezoides.
V. Os Magnum.
W. Os Unciforme.
X.X. Metacarpal Bones.
Y.Y. Phalanges of the Thumb & Fingers.
Z. Os Pisiforme.
Α. Head of the Os Femoris.
Β.Β. Cervix Femoris.
Γ.Γ. Trocanter Major.
Δ.Δ. Trocanter Minor.
Ε.Ε. Body of Os Femoris.
Ζ.Ζ. External Condyle of Femoris.
Η.Η. Internal _ D^o.
Θ.Θ. Head of Tibia.
Ι.Ι. Body of _ D^o.
Κ.Κ. Base of _ D^o.
Λ.Λ. Internal Malleolus.
Μ.Μ. Head of Fibula.
Ν.Ν. Body of _ D^o.
Ξ.Ξ. External Condyle.
Ο.Ο. Astragalus.
Π.Π. Os Calcis.
Ρ.Ρ. Tuberosity of Os Calcis.
Σ.Σ. Os Naviculare.
Τ.Τ. Os Cuboides.
Υ.Υ. Os Cuneiforme Internum.
Φ.Φ. ________ Medium.
Χ.Χ. ________ Externum.
Ж.Ж. Metatarsal B…


2. Vertebræ of the Neck.
Atlas from beneath.
Atlas from above.
Axis.
Fourth Vertebra side view.
1. The Spine
A front. B side. C back.
3. A Vertebra of the Back.
upper view.
under view.
side view.
4. A Vertebra of the Loins.
upper view.
under view.
joint of rib with Vertebra.
7
8
Sternum or Breastbone
A. side view
B front "
C back "
5
The Ribs and breastbone.
6
Upper Rib.
Middle Rib.
Eleventh Rib.
9
Ligament attaching rib to breastbone.
10
From above (male)
13
Os Sacrum
11
From right side.
12
14

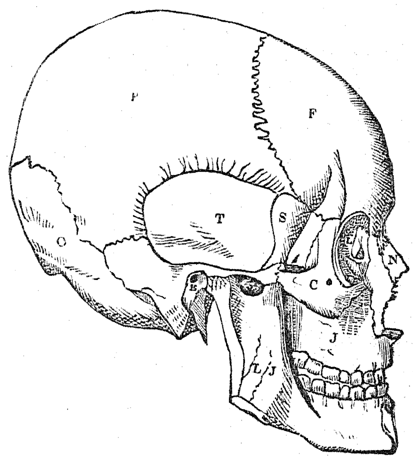
arms and head, to pass down, and their arteries to pass up. The inferior opening of the chest is large, and is bounded by a muscle named the *diaphragm* (a Greek word, which literally means *the partition*), because it separates the belly from the chest, forming a roof for the one and a floor for the other. The chest is considerably deeper behind than in front, and the edges of the cartilages of the ribs can be felt, and, in a thin person, seen passing upward from the flanks, and meeting at an angle with the breastbone, leaving a hollow between them, which is known as "the pit of the stomach."

The *pelvis* (see figs. 10, 11, and 12, Plate III.) is so named because it is somewhat like a *basin*, only that it has a wide aperture in the bottom, through which the canals from the bowels, the bladder, &c., make their exit. It consists of three distinct parts, the two hip or haunch-bones and the rump-bone. The last part is a curved wedge called the *os sacrum* (shown in fig. 13), but which sometimes receives the name of the *false vertebræ*—for in the young subject it consists of five pieces, which are *real* vertebræ, but in the adult these are firmly united into one, convex behind and concave in front. It is of a triangular form, having the base above and the point below. It has a large articular surface, *c*, on each side, for union with the pelvis, and the spinous processes of its originally separate bones are shown at *d d*. The articulations with the last vertebra of the loins are at *g e*, and that with the four bones of the os coccyx, at *f*. The spinal canal continues between the body and the spinous processes, but is more or less open, like a narrow gutter.

The tail in man does not, as in many animals, project from the body, but it exists in four small bones which in the adult grow together, showing their former separation by slight markings (see fig. 14). This bone has no canal for the spinal cord. The upper piece, *a b*, has a pair of small processes which connect its hind part more firmly to the os sacrum, but neither of the other pieces, *d e f*, has any process. The portions of the pelvis which form its sides are of a very irregular shape. They make an irregular bony ring attached at the back to the os sacrum, carry the lower limbs, and protect some of the most important organs of the body, which lie within it. The upper part of the bone is fan-shaped, and forms the hip; it is the point of attachment of the great muscles, preserving the vertical position of the trunk on the thigh-bones, and contains the socket, *r* (fig. 11), of the hip-joint. It has four little jutting processes, *a b c d*, and its upper margin, *e*, is called its crest. The outer surface, *f*, is called its back, and the inner, *g*, its belly—the latter being bounded by the ilio-pectinial line, *h*. This is the *ilium* or hip-bone, and is one of three pieces of which the pelvic bone is composed in infancy, though in the adult it is one solid mass. Following the hip-bone is the *pubis* or haunch-bone, which assists in forming the socket, *r*, and thence proceeds by *i* and *l* to its junction with its fellow of the other side in the *symphysis pubis*, *k*, which completes the girdle. The *ischium*, or share-bone, is the third portion of the pelvis, and carries the tuberosity, *m*, on which the body rests in the sitting posture. It completes the socket *r*, and has a spinous process, *n*, dividing its outline into two notches—the greater (*p*) and lesser (*o*) ischiatic curves.

The pelvis gives a somewhat cylindrical cavity, the broad spread-out upper part of it, of a somewhat heart-shaped figure, being called the false basin; the true basin, *h*, is below the brim, and is circular in the male and oval in the female. The front and sides of the true basin are formed by the pelvic bones, the back by the os sacrum and the os coccyx. It is evident, therefore, that it is not a complete bony ring, like the false basin, but is made of three bony angles depending about an inch from the brim of the pelvis, ending in the tail-bone and the tuberosities (*m*) of the ischiatic bone.

The *head* is placed upon the atlas, the first cervical bone at the end of the spinal column. The atlas interlinks with the axis (fig. 2, Plate III.), the second cervical bone, in order that the brain may be connected with the spinal cord. It occupies this position that the eyes and ears which are set in it may enjoy the widest possible range of sensation. It consists of two parts, the *cranium* and the *face*; the former contains the brain, the latter the organs of sight, smell, and taste. The cranium is very nearly of the shape of an egg, the larger end being backward and the smaller one forward, presenting thus the characters and having the strength of a double dome. The upper dome is, however, stronger than the lower one; and hence we find that when a man falls from a height on his head, the fracture is most frequently not at the part struck, but at the base. The face cannot be compared to any known regular figure; it is hollowed into several cavities, one large one for the mouth, another of considerable size for the nose, and two smaller pyramidal ones for the eyes, called the orbits. The number of bones in the head, exclusive of the teeth, is twenty-two.



Profile View of the Human Skull.

F, Frontal bone; O, occipital bone; J, upper jaw-bone; L, lachrymal bone; P, parietal bone; S, sphenoid bone; L, J, lower jaw-bone; E, opening into ear; T, temporal bone; C, cheek-bone; N, nasal bone.

The *cranium* or brain-case is composed of eight bones, which are mostly of a flattened form, convex externally and concave internally. The *frontal* bone forms the forehead, and the roofs of the orbits or eye-sockets; the *occipital* bone forms the back and under part of the head. The large hole through which the spinal cord passes down from the brain is in this bone. The two *parietal* or wall-like bones meet in the middle and form the upper and side parts of the head. In the centre of each of these bones there is a protuberance giving the greatest breadth to the head. This line of greatest width is generally rather further back than the middle of the head. The *temporal* bones are named from the Latin word *tempus*, signifying time, because on the hair covering them the traces of time are first manifested. They are placed one on each side, occupying the inferior lateral parts of the cranium, and extending into its base. In each is seen the funnel-shaped opening which admits the waves of the air to the drum of the ear, called the external auditory canal, to the edge of which the external ear is appended. The hard part of each, extending into the base of the cranium, contains the essential part of the organ of hearing. The two remaining bones are placed at the base of the cranium, and belong equally to it and to the face. The delicate and complex *ethmoid* or sieve-like bone is so named on account of its upper plate being perforated with forty or fifty holes, through which the twigs of the olfactory nerves pass into the nose. A small part of it forms a portion of the inner boundary of the orbit, but this cannot be seen in the engraving. The *sphenoid* or wedge-like bone is so named not from any similarity to a wedge in shape, but from its being wedged in among so many other bones; for it is united to the other seven bones of the cranium, and to five of the face, all of which it in a great measure serves to bind together. It is to be noted that the tympanic ossicles (or bones of the ear), the teeth, and the *ossa triquetra* (three-cornered) or Wormian bones are not included in the foregoing enumeration.

In an adult man on each side of each jaw there are two incisor, one canine, two premolar or bicuspid, and three molar

teeth, which may be represented readily in the following dental formula :—

$$\textit{Incisors}, \frac{2-2}{2-2}; \textit{ Canines}, \frac{1-1}{1-1}; \begin{matrix}\textit{Premolars} \\ \textit{or} \\ \textit{Bicuspids},\end{matrix} \frac{2-2}{2-2}; \textit{ Molars}, \frac{3-3}{3-3}.$$

The cranium is constructed in such a way as to give the utmost possible protection to its important contents—the brain. By its rounded dome-like shape not only is its strength increased, but blows tend to glide off it without doing material damage. The curved lines of its different sections, and the mutually fitting indentations by which these parts are dovetailed, together tend to the same end. Each one helps to strengthen and buttress the other. It is on this account that concussion of the brain so seldom proves fatal unless accompanied also by fracture of the skull.

The vault of the cranium is smooth and regular where it forms a protective roof for the brain. The floor of it is divided into deep hollows, for containing the different lobes of the brain. Numerous holes exist in the base of the cranium, for the entrance of the nourishing arteries of the brain, for the exit of its veins, and for the passage of the numerous nerves which connect it with the organs of the senses and with the other parts of the body.

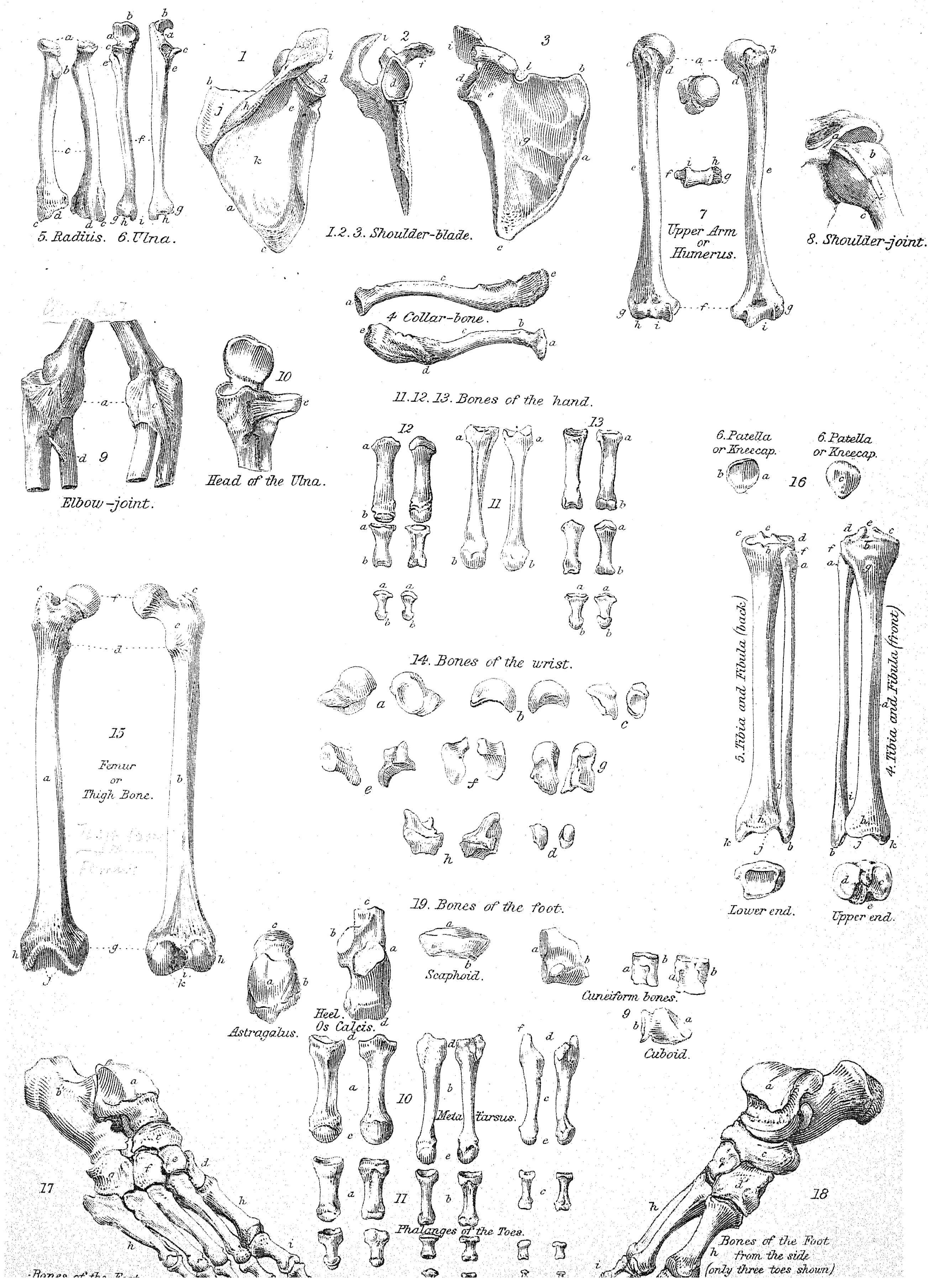
The *face* consists of fourteen bones, six in pairs and two single ones. The two *upper maxillary* or *jaw-bones* form the principal part of the face. They meet in the middle, form the arch in which the upper row of teeth are set, and extend backward, making the principal part of the roof of the mouth. A process runs up from each, separating the cavity of the nose from that of the orbit. In order that the face may be lighter, the body of the upper jaw-bone is not solid, but hollow. The cavity communicates with the nose. The roof of the mouth is completed by the two *palate-bones.* The firm part of the nose, from its roof to its bridge, is formed of two small pieces, meeting in the middle, called the *nasal bones.* These are liable to be broken or knocked in by a blow, an injury which occasions great disfigurement. The opening of the nose in front is seen in the skull to be of an oval figure, bounded by the two nasal and the two upper jaw-bones. Flanking the lower and outer parts of the orbits or eye-holes are the two *malar* or *cheek-bones*, making the prominences on the sides of the face. At the inner sides of the orbits are two little bones of the size and shape of the finger nail, called the *lachrymal bones*, because they form the chief part of the canals through which the tears find their way into the nose. Forming the partition of the nose is a bone resembling a ploughshare in shape, whence its Latin name *vomer;* and within, on each side, are the two inferior turbinated bones for extending the olfactory surface. Finally, the inferior maxillary or *lower jaw-bone* is a single dental arch equalling in size that formed by the upper jaw-bones, and containing as many teeth. The forepart of this bone is the chin, extending back from which, and gradually separating from each other, are its sides, which terminate at the angles, and from the angles the branches rise nearly perpendicularly upward, to be attached by movable joints to the sockets prepared for them in the two temporal bones. The hinder of the two protuberances on the upper side of the back of the under jaw, by which that jaw is articulated into the glenoid cavity of the temporal bone, are called condyles or condyloid processes. Condyle (Gr. *kondylos*, a knuckle) is the name usually given to any rounded protuberance or raised lump at the end of a bone.

Though composed of so many pieces the whole head moves as one mass on the axis or the second vertebra. The only motion that takes place between its parts is the opening and closing of the mouth. This is done by the lower jaw dropping and being again lifted, while the upper jaw remains unmoved.

The *orbits* are two cavities placed in the face for containing the eyes. Each orbit is of a conical figure, the apex being behind, where the optic nerve enters it, and the base being in front. It is much larger than is necessary for the size of the eye alone—this delicate organ being cushioned on a quantity of soft fat, in order that it may move with the greatest ease in every direction. The inner walls of the orbits are parallel, while their outer walls diverge widely from one another, to give the eyes the advantage of as wide a range of vision as possible.

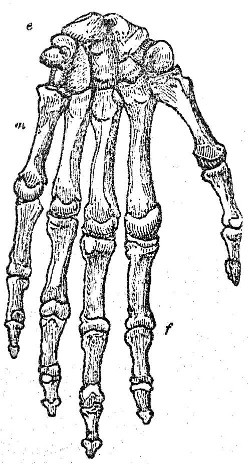
In all vertebrate animals the limbs are formed on a similar type or plan, modified of course to suit each special creature. The upper and lower extremities have a strong general resemblance to each other. The shoulder may be said to correspond to the pelvis, the arm to the thigh, the forearm to the leg, and the hand to the foot; but the differences between them are also very striking. The lower limbs are formed for progression, and for supporting the weight of the rest of the body; the upper for prehension—and they are much less strong, but much more movable. The shoulder is not fixed immovably to the trunk—the shoulder-blade glides on the back of the ribs, and is joined firmly to the outer end of the collar-bone; and the inner end of this is connected to a socket on the upper corner of the breast-bone. This permits great freedom of motion, and forms a centre round which the shoulder plays, so as to be raised or depressed, or carried forward or backward.

The *clavicle* (Lat. *clavicula*, a small key) or *collar-bone* (fig. 4, Plate IV.) is slender, curved like a long italic *f;* and as all shocks produced by falls on any part of the upper extremity are transmitted through it, it is one of the bones most frequently broken. At *a* is the flattened surface by which it articulates with the breast-bone, and at *e* a small surface, also flat, for the articulation with the shoulder-blade. The *scapula* or *shoulder-blade* (shown in three positions—figs. 1, 2, 3, Plate IV.) is triangular, with one angle directed downward, one upward, and one outward, and it covers the ribs from the second to the seventh. It is not, however, attached to the ribs, but is separated from them by a cushion of muscle upon which it glides. Its outer surface, *k*, is convex, and its inner, *g*, concave and smooth; it extends along the first seven ribs, so as to form a protection to the posterior parts of the inclosure of the chest. By the acromion arch (Gr. *akros amos*, the top of the shoulder), *h*, which overhangs the shoulder-joint, it gives its natural roundness to the shoulders; and by a singularly curved projection, called, from its likeness to the back of a raven (Gr. *kŏrax*), the coracoid process, *f*, it provides points of attachment for many useful muscles. At its external angle there is a shallow glenoid cavity, *d*, or receiving socket for the arm bone, so shallow that this bone is not laid into but merely against it—an arrangement which explains the frequency of dislocations of the shoulder-joint (fig. 8, Plate IV.) The line *b a c* is called the base, and lies parallel to the spine. The upper edge is nearly vertical, and the edge *d c* diagonal The *humerus* (fig. 7) or bone of the upper arm is single, attached above to the shoulder-blade, and below to the bones of the forearm. It has a large round head, which is united by a ball-and-socket joint with the shoulder (see fig. 8), capable of very free motion in every direction; and by a hinge-joint with the forearm (fig. 9), capable only of flexion and extension. It has two projections, externally and internally, just above the elbow, which give the breadth to this part of the limb, and to which the muscles of the forearm are attached. The bones of the *forearm* are two, the *radius* and the *ulna*, the former being on the outer or thumb-side and the latter on the inner. The ulna (fig. 6) is connected chiefly with the elbow-joint, and the radius (fig. 5) chiefly with the wrist; so that when a fall is received on the hand the force is transmitted through the radius much more than through the ulna, and hence the radius is more frequently broken than any other bone in the body. The ulna is articulated to the arm-bone, and moves on it in flexion and extension; it can be bent up very close to it, and may even be extended very nearly into a straight line with it. It is irregularly triangular in section with a cavity called the *sigmoid* at top, *a*, which fits and turns on the pulley-like head of the humerus (fig. 7), and is protected by the *olecranon*, *b*, or point of the elbow. The radius is very slightly connected with the arm-bone, and has a round head received into a cavity, *e*, in the outside of the ulna, while at its lower end it has a cavity, *d*, in its inner side, which rolls round the small lower end of the ulna at *g*. The effect of this arrangement is, that the ulna has always the same face directed forward, while the radius can roll round the ulna, so that its edge, or even its back, can be


5. Radius. 6. Ulna.
1.2.3. Shoulder-blade.
7 Upper Arm or Humerus.
8. Shoulder-joint.
4 Collar-bone.
Elbow-joint.
Head of the Ulna.
11.12.13. Bones of the hand.
6. Patella or Kneecap.
6. Patella or Kneecap.
5. Tibia and Fibula (back)
4. Tibia and Fibula (front)
Lower end.
Upper end.
15 Femur or Thigh Bone.
14. Bones of the wrist.
19. Bones of the foot.
Astragalus.
Heel. Os Calcis.
Scaphoid.
Cuneiform bones.
Cuboid.
Meta tarsus.
Phalanges of the Toes.
Bones of the Foot from the side (only three toes shown)

turned forward, carrying the hand along with it. This motion is commonly said to take place in the wrist, but in reality the wrist has nothing to do with it. It is called *pronation* and *supination;* the hand is said to be *prone* when its back, and *supine* when its palm, is turned upward or forward. It is in this motion that the greatest difference is observable between the forearm and the leg; had any such motion been permitted in the leg it would have produced instability. These two bones are connected in their whole length by a strong membrane, which, while it does not interfere with the rolling motion, affords points of origin to muscles. The circular coronary ligament, *e* (fig. 10), forms a collar round the neck of the radius close to the elbow, confining it to the cavity of the ulna, and therefore compelling it to move like a pivot in a socket, while the base of the radius is free to travel round its curved articulation, *g*, on the ulna, in a semicircle. The two extremities of the ulna, both upper and lower, are readily felt in the living limb, and afford a very ready standard of measurement from the elbow to the finger points, called the cubit, from the old Latin name of the bone, *cubitus*.

The *hand* consists of twenty-seven bones, and is divided into three parts, which are analogous to those of the foot. The solid part entering into the wrist-joint is properly called the *carpus*, or wrist, corresponding to the *tarsus* in the foot, but for obvious reasons greatly smaller, both in itself and in relation to the rest of the hand. Five long bones come next, making the palm or metacarpus, and fourteen very movable pieces superadded complete the fingers and thumb. Fig. 11, Plate IV., shows a detached metacarpal bone in two positions, front and back, fig. 12 the three bones of one of the fingers in similar positions, and fig. 13 those of the thumb. The letters on each bone indicate the mode in which they are joined to form the hand. In its construction the whole hand differs from the foot, on account of its being intended, not for support, but to catch with, and all its parts are adapted to this end. Eight small bones are pretty firmly united to form the wrist (shown in fig. 14, Plate IV., in which *a* is the scaphoid, *b* the semi-lunar, *c* the cuneiform, *d* the pisiform, *e* the trapezium, *f* the trapezoid, *g* the great, and *h* the unciform bone), presenting a ball superiorly (*i.e.* towards the top part) to enter the cavity in the lower end of the radius, fitted inferiorly (*i.e.* towards the lower part) to support the bones of the palm, arched behind to give it strength, and concave in front to permit the bloodvessels, veins, and sinews to run to the fingers, without being subjected to undue pressure. In the palm we see the principal difference between the hand and the foot. In the latter all the bones of the instep lie in one direction, immovable, and serving only to rest on. In the former, four of the bones of the palm are placed side by side, to form the hollow of the hand, and to support the fingers; while another, supporting the thumb, is very movable, being capable of being brought opposite the others, so as to grasp firmly anything between it and them. The pieces of the fingers are considerably larger than those of the toes, and much more movable, but are formed on a similar model. The fingers have each three pieces, the thumb only two. The last piece of each is expanded at the end, to support the nail on its back, and on its front the delicate pulp where the nerves ramify, and in which the nicest sense of touch resides.



Front View of Left Hand.

c, The eight bones of the carpus; *m*, the five bones of the metacarpus; *f*, the fourteen pieces of the fingers and thumb.

The *lower extremities* consist each of thirty bones. The *thigh* contains a single bone, the *femur*, the largest in the whole body (shown from both sides at *a* and *b*, fig. 15, Plate IV.) It has a long shaft, from which a neck, *e*, goes off at an obtuse angle, surmounted by a smooth globular head, *f*, covered with cartilage, which is received into the cuplike socket of the *acetabulum* of the pelvis. Where the neck of the bone joins the shaft there are two prominences, *c* and *d*, which serve as levers for the attachment of strong muscles. The lower ends of the thigh-bones, *g*, are large, and rest on the heads of the shin-bones. Their lower ends are much nearer one another than their upper ends, thus bringing the points of support underneath the weight of the body. The bones of the leg are two, and are shown in two positions in fig. 16. The *shin-bone* (*tibia*), *g h*, is the inner and the larger, placed perpendicularly under the body; it has a broad end above to articulate with the thigh-bone, and a smaller one below to unite with the foot in the ankle-joint. One of its ridges, known as the shin, is felt under the skin the whole way down. The outer slender bone, called the *fibula*, *a*, *b*, passes from the upper end of the shin-bone to the lower; it is connected with the ankle-joint, but forms no part of the knee-joint; it has no connection with the thigh-bone, and therefore supports no part of the weight of the body. It serves to increase the breadth of the leg, without adding much to the weight, and is connected in its whole length to the shin-bone by a strong membrane, or *interosseous ligament*, which serves to give attachment to muscles as well as if it had been bone, with the advantage of being much lighter. The lower ends of these two bones make the projections which are called the inner and outer ankles.

Intermediate to the thigh and leg is the sesamoid bone (Gr. *sesame*, a bean-like grain), called the *patella* (Lat. *patella*, a flat saucer-like dish) or *knee-pan* (also shown in fig. 16)—a bone which has no correspondent one at the elbow in the upper extremity. It glides on the smooth anterior part of the thigh-bone, is attached to the shin-bone by a strong ligament, and has the powerful extensor muscles of the leg inserted into it. It increases the power of these muscles, by throwing their attachment forward, and therefore further from the centre of motion of the leg, thus conferring on them the advantage of an increased lever power.

The *foot* consists of twenty-six bones (figs. 17, 18, and 19, Plate IV.) Seven of these form the *tarsus* (Gr. *tarsos*, any broad, flat, interwoven, wickerwork-like surface), or solid part of the foot, to which no English word corresponds. Five compose the instep, or *metatarsus*, and the remaining fourteen are the joints of the toes. The uppermost of the bones of the tarsus—called from its likeness to Roman dice the *astragalus* (*a*, figs. 17 and 18)—is shaped above like a pulley, and is received between the projections of the two bones of the leg forming the two ankles, so that by its motion the foot is bent up at right angles to the leg, or pointed with the toes downward. The *os calcis* or heel-bone (*b*) projects nearly an inch and a half backward, giving a strong lever for the insertion of the powerful muscles which form the calf of the leg. The next bone—the scaphoid (*c*)—is in front of the pulley-like bone, and in some persons is very movable, admitting of much lateral motion across the middle of the foot. Three cuneiform (*d*, *e*, *f*) and one cuboid bone (*g*), in front of these, complete the tarsus, and support the instep. The five bones of the metatarsus (*h h*) are each about 2½ inches long; they are attached posteriorly to the solid part of the foot, and anteriorly they support the toes. Their front ends rest upon the ground in standing, so that the foot presents an arch—the end of the heel-bone behind, and the ends of the metatarsal bones in front, being the abutments, while the pulley-like bone is the keystone on which the weight of the body rests. This arch is not, however, firm or rigid, but yields a little when leant on; and to prevent its yielding too much, is strengthened below with strong plantar ligaments, passing like a bow-string from behind forward. The degree of hollowness is very dissimilar in different persons. Those in whom the arch of the foot is most developed make the best and most active pedestrians. The foot is likewise arched from side to side; and in the hollow thus gained, the blood-vessels, nerves, and tendons, going to the toes, lie safe from injury by pressure. The metatarsal bone of the great toe is much stronger than that of any of the others. To this toe there are only two movable pieces, much larger than the joints of the other two

Each of the smaller toes has three pieces (*ii*) similar to the joints of the fingers, but much smaller, as they are not intended for grasping. The last piece is enlarged towards its point, for supporting the nail on its upper, and the pulpy extremity of the toe on its lower surface.

Let us endeavour now to group before our mind's eye, in some intelligible form, the disposition and arrangement of that bony structure which we have been studying, as a concise ideal of the general build of the skeleton of the human body. See and refer to Plate I.A.

Upper Extremities.	Central Trunk.	Lower Extremities.
ARM (30 bones).	I. HEAD (22 bones).	LEG (30 bones).
1. Humerus—1.	1. Cranium, consisting of—	1. Femur—1.
2. Forearm. Radius & ulna—2.	*a* Frontal—1.	2. Leg—3. Tibia and Fibula (with Patella).
3. Hand.	*b* Temporal—2.	
(1) 1st Carpal row.	*c* Occipital—1.	3. Foot.
a Scaphoid.	*d* Parietal—2.	(1) 1st Tarsal row.
b Semi-lunar.	*e* Sphenoid—1.	*a* Scaphoid.
c Cuneiform.	*f* Ethmoid—1.	*b* Astragalus.
d Pisiform—4.	2. Face (14 bones).	*c* Os calcis—3.
(2) 2nd Carpal row.	*a* Nasal—2.	(2) 2nd Tarsal row.
a Trapezium.	*b* Up. maxillary—2.	*a* 1st Cuneiform.
b Trapezoid.	*c* Malar—2.	*b* 2nd Cuneiform.
c Os magnum.	*d* Lachrymal—2.	*c* 3rd Cuneiform.
d Unciform—4.	*e* Vomer—1.	*d* Cuboid—4.
(3) Metacarpal row—5 (one articulating to each finger).	*f* Lower maxillary—1.	(3) Metacarpal row—5 (one articulating to each toe).
	g Palatal—2.	
(4) 1st Phalangeal row—5.	*h* Inferior Turbinated—2.	(4) 1st Phalangeal row—5.
(5) 2nd Phalangeal row—5.	II. TRUNK.	(5) 2nd Phalangeal row—5.
(6) 3rd Phalangeal row—4.	1. Scapula—2.	(6) 3rd Phalangeal row—4.
	2. Clavicles—2.	
	3. Sternum—1.	
	4. Ribs—24.	
	5. Vertebræ.	
	a Cervical—7.	
	b Dorsal—12.	
	c Lumbar—5.	
	Pelvis.	
	(1) Ilium.	
	(2) Ischium.	
	(3) Pubis.	
	d Sacrum—(5.)	
	e Coccyx—4.	

BOOK-KEEPING.—CHAPTER I.

COMMERCE—BOOK-KEEPING DESCRIBED AND DEFINED.

COMMERCE has, in almost all lands, necessarily formed one of the chief practical interests of the human race. Through a long course of ages men have been engaged in bartering and exchanging, buying and selling, holding markets, and seeking the profits and advantages of merchandise. The interchange of the products and commodities of one place, country, or person for those of another constitutes commerce, which Dryden describes as the art of life—

> "By which remotest regions are allied
> Which makes one city of the universe,
> Where some may gain and all may be supplied."

Trade causes a continual shifting of articles from one to another, and carries on in the world the work of distribution. In the olden time the people of Phœnicia went out from their narrow and mountainous country, carrying forth the products of their land, and bringing back the ores and wares which other nations had. They contributed in their course to spread among the nations the use of weights and measures, the arts of writing and arithmetic. In a wonderful vision by Ezekiel (xxvii.) we get a striking glimpse of the extent of the commercial dealings of Tyre; its trade, its wares, its luxuries, and its fairs. Landward and seaward they were the pioneers of commercial enterprise, and their territory was the emporium of the world. Greece, in the heroic ages, was careless of trade; but ultimately it learned to import and export, and to find wealth in commerce. Plato speaks of illiberal huckstering as a crying scandal in his day. The Romans left commerce, for the most part, in the hands of foreigners, freedmen, and slaves; although towards the close of the Republic joint-stock companies of wealthy men engaged in banking, farming the revenues, and commercial enterprises. But they were not normally a trading race. Trade, as an exchange of commodities, must always have remained barter had not a standard of value been settled upon, and so furnished a means of determining in some measure a market-value of goods. When money was employed as the common measure of exchanges, commerce as a business became possible, and some system of recording the results of trade became indispensable. Every seller of goods is in reality a buyer of money, and every purchaser of goods is a seller of money. Money is a representative of the exchange value of wares, and calculation in money made book-keeping a possibility.

In every department of human activity practice precedes science. Hence for a lengthy period men doubtlessly made numerous efforts to discover a useful practical form of keeping accounts of their property, with details of the changes made in it by consumpt and trade, and so making some fairly accurate estimate of its actual worth or relative value at stated periods. Passages from several of the classics have been quoted to prove that the ancients possessed a practical knowledge of book-keeping; but we have no specimens of their form of arranging their records of commercial transactions, and of deducing thence a knowledge of their profits or losses. It is probable that the introduction of the Arabian numerals, and the consequent simplicity and facility of stating and working sums in arithmetic, aided considerably in enabling merchants to arrange such calculations as exhibited the precise condition of their business. In point of fact, however, we are utterly unacquainted with the name and age of the ingenious contriver of the system of accounts which enables the man of business (1) to state with clearness every fact which concerns the increase, diminution, or exchange of the constituent portions of his estate, and (2) to ascertain with certainty and at once the precise result of all the operations which have taken place on or with his stock, as merchandise, at any time he may wish to do so. It would be difficult to overrate the value of this scientific yet practical art, and it is matter of surprise that any man engaged in business—in which the utmost accuracy of accounts is essential—should disregard the study or neglect the use of it.

It was in the commercial communities of the seaboard of the Mediterranean that book-keeping took its rise. Genoa, Pisa, and Venice contend for the honour. The fifteenth century seems to be the most nearly ascertained date of its general introduction. The first known systematic treatise on book-keeping was published in the Italian language in 1494. Its author was a mathematician and a monk named Lucas di Burgo. In Italy, France, England, Germany, Holland, and America a great variety of treatises on this subject have since been produced.

The principles of book-keeping have now been reduced to scientific certainties; the methods of recording and working out the results of all business transactions are simple, well-tested, and efficient; and the division of labour and of responsibility are capable of being so thoroughly and carefully arranged that every case can be immediately investigated, traced, and tested. It is a scientific art, founded on defined principles, accepted by the reason, and readily acted upon by those who have studied the elements; while at the same time it is possible so to divide the several matters of business detail that many people may be intrusted with the registration of transactions who yet need never know the various processes through which the entries pass, in the accountant proper's hand, in their passage towards the final balance-sheet, which shows the state of business.

It is reasonable to conclude that in a commercial country like ours, where so much depends on the accuracy of many complicated calculations, and on the carefulness with which every detail entering into business is conducted, the art of book-keeping is a most important one. We may readily believe, too, that when so many have been engaged in conning over the principles and testing the practices which prevail in the counting-house, the excellence and exactness attained must be very considerable, and the elaboration which results

in simplicity must be very complete. Many large and erudite philosophical works have been written, and many different suggestive systems have been devised and employed, to teach how to keep, arrange, and balance mercantile accounts. These are all more or less abstruse, because they have been for the most part planned on the principle of carrying the transactions through all the possible forms of entry and transfer, and so have complicated in teaching what ought to have been seen to be quite simple in use. Most of the treatises on this subject have been too formal (though they could not be too precise), and the appearance of pedantry in many of them has helped to make them seem too exacting. Business is so various that no possible "set of books" can be made to exemplify all the processes and checks which are requisite in the different branches of commercial enterprise; and the introduction of many forms, which are unnecessary in the ordinary run of counting-house experiences and the practice of individual firms, has had the effect of making "Systems of Book-keeping" rather contemned than studied. It is well known that there is no formal, "cut and dry" set of exemplary books which will enable a lad to leave school and pass into the counting-house immediately *au fait* at keeping the business books of an office. Special differences exist in all businesses, and these require adaptive training. But a fair acquaintance with the principles and familiarity with the practices of book-keeping as taught on a good system have real advantages, which are not to be despised. The examples wrought by a boy while engaged in the study of arithmetic may be very different from the sums which will demand his attention when he quits the class and begins his business life; but his perception of the principles and his dexterity in the operations of arithmetic stand him in good stead at the desk or the counter. The same ought to be the case with a fairly arranged and intelligibly explained system of commercial book-keeping. The principles should hold true all through, and the practice obtained ought to be worth for so much—even though not immediately, in the very selfsame form, adapted to use in the special business in which he is employed. The system, if scientific, should be trustworthy, and the forms, if rightly taught and understood, ought at least to be easily adaptable to the methods required and in use. If not quite similar they will be pretty analogous. With less outward regard to system, perhaps a method might be arranged which would be more truly systematic, if system is the exposition of a doctrine in such a way as to make it at once scientific and serviceable.

It is easy to advocate, as a scientific basis for book-keeping, the adoption of a certain number of the axioms of geometry, or of the principles on which algebraic equations depend. That things which are equal to the same thing are equal to one another, that the whole is greater than its part, and that the sum of all the parts is equal to the whole, are quite indubitably true; but it is not necessary to assume, as has indeed been done, that the principles of book-keeping have been deduced from these recondite statements. Book-keeping is the result of actual experience, has its origin in the necessities of traders, and is less scholastic in its form than that idea implies. Its real basis is common sense, and the best means of learning it is practice. But for all that, any person interested will find that, when he has made himself thoroughly conversant with its principles and their applications to commercial requirements, he will have learned something having a distinct practical utility, and have acquired knowledge which will enable him to do his duty better not only in mercantile but in common life.

Book-keeping is the art of registering mercantile transactions in such a way as to secure that they are (1) correctly stated; (2) able to be easily referred to; (3) so arranged as to be accurately and distinctly understood; and (4) ready, at any desired time, to be exactly balanced. It presents the history of a merchant's business transactions in such a methodical form of record as to show at any time the precise state of his affairs. However the details of book-keeping may differ according to the extent and nature of the commercial transactions to be recorded, the books in which the register of them is made require to be kept neatly as regards penmanship, ruling, &c., accurately in statement and form, perspicuously in plan and expression, and safe from damage, loss, or alteration. The books employed are usually prepared, ruled, and made up to suit different classes of traders and kinds of businesses. In the writing out of them there should be no erasures or blots, and no leaves should ever be missing from any one of them. They are usually placed in the charge of skilled clerks, and it is customary to put them in a fireproof safe or otherwise when not in use at the desk. Commercial books are regarded as of a very important character. They are the record of the trader's transactions, and ought to be kept with such care as to enable him periodically to satisfy himself, or (if need be) his creditors, of the state of his affairs. They contain the record of other people's transactions with him, and for their sakes too it is essential that the entries be correct, the posting exact, and the particulars trustworthy. For these reasons all intricate and over-elaborate methods should be avoided, and simple, easily-understood, and self-checking forms ought if possible to be used. That system of book-keeping is best which best fulfils the aim of the man of business. This is to possess an exact and distinct record of his transactions, so arranged that he may perceive at once the condition of his business, the number and magnitude of his transactions, the amount of his outlay and income, and the extent of his profits (or losses). Good book-keeping protects honesty and defeats fraud, facilitates scrutiny, and expedites the settlement of accounts. It saves time, means, temper, and reputation.

Of course, the property which is the object of commerce is in a continual state of alteration. It is constantly changing hands, being divided in quantity, distributed among new possessors, and so scarcely ever for long in the same condition. Every incident, in relation to this property, requires to be recorded (1) in the simplest form, (2) with the utmost clearness, and yet (3) with all the essential details of each accurately given—such as (i.) the property or commodity (whatever it is) which has changed hands (or place); (ii.) the day on which the change occurred; (iii.) the person from whose charge it has passed; (iv.) the person into whose hands (or care) it has passed; (v.) the price at (or the purpose for) which it has so passed; (vi.) the condition of payments (or return), whether immediate cash, bill, barter, commission, &c.; (vii.) the change thus made in stock, cash, bill, &c., and any other particulars of special interest. Everything that enters a commercial establishment in the way of trade, whether at its commencement or in the course of its dealings, is of course "property" or "stock," and is to be accounted for from its entrance into the business till its final leaving it. To do this accurately, expeditiously, briefly, clearly, completely, in elegant writing and neat form, is to attain in regard to it the aim of book-keeping as an art.

As a science book-keeping examines all the incidents of trade, arranges the facts it learns concerning it, classifies them, and studies them so as to see into what uniformities of operation they fall and into what groups of relations they settle. It then seeks some systematic view which will bring all these incidents in an orderly manner before the mind, and forms a theory—or mental view—of the principles which underlie the whole body of commercial transactions, with the design of discovering some general series of truths which explain the correctness of the operations it proposes and the trustworthiness of the forms it recommends, and which are alike applicable to every business. This series of truths constitute the principles of book-keeping, and these, if carefully observed and acted upon, secure the correctness of the details which arise in the experience of trade.

THE CASH-BOOK.

All accounts are kept in *money*—the commercial name of which is *cash* (from French *caisse*, a money-chest). It is used to signify coinage or notes (equivalent to coined money) as distinguished from *produce;* and money in hand or at command for exchangeable purposes as distinguished from *bills*, *drafts*, and *securities*, or other negotiable instruments which pass current by indorsation, &c., as well as from goods, labour, &c., convertible into money or exchangeable in barter. A *cash-book* is a book in which a register or account of money is kept. Money is continually changing hands, being received or disbursed for different purposes and in

varying amounts. If goods are bought or labour is employed money has to be paid for them or it, and if goods or labour is parted with money requires to be got in exchange. Income and expenditure are thus constantly changing their relations. A register of all receipts and all payments must therefore be accurately kept if we would know rightly what has occurred with regard to money in possession or laid out. Every person, whether engaged in what is technically called *business* or not, must find it advantageous to know exactly how his income and expenditure stand in regard to each other. This presents the simplest possible case for the employment of book-keeping in the form of a cash-book. It is usually kept in a folio form, with a right and a left hand page opening before the cashier (or person keeping the account of monetary transactions). On the corner of the left-hand page the sign Dr. (an abbreviation for *debitor* or *debtor*, one under obligation to pay) is written; and on the similar corner opposite, on the right-hand page, is engrossed the sign Cr. (signifying *creditor*, one in whom confidence is or has been placed). On the left-hand folio the word CASH, and on the right the word BOOK should also be written in large hand as a title. In this book all distinctly monetary transactions are to be regularly and accurately recorded—that is, each sum of money received and each paid away must be duly entered, the former on the left-hand page, the latter on the right. The formula for regulating the entry may be briefly given as "In, Dr.; out, Cr.;" in other words, every sum paid *in* is entered on the Dr. side (left), and every sum paid *out* on the Cr. (right) side of the folio.

Properly speaking, a cash-book is only a part of a day-book—a book to be afterwards described—separated from the general day-book in which business transactions are noted, and devoted to the special object of keeping in a ready and handy form a record of the transactions in cash which have taken place, because it is more convenient to have them brought all at one view before one than to have them intermixed with others. By its use we avoid the delay which would arise from selecting the sums received and paid from the various other transactions, and of assorting them into received and paid, *i.e.* Dr. and Cr. entries.

In the language of book-keeping, a folio-form (Lat. *folium*, a leaf), signifies the two pages, left and right, which lie before us when an account-book is opened, on the former of which Dr. and on the latter of which Cr. entries are written.

A cash-book folio should show (1) the actual sum of money on hand at the date of the first entry; (2) what has been paid *in*, and what has been paid *out*, during the course of the time employed in filling it; and (3) the precise amount of the cash in hand at the time of balancing the folio. The cash-book should be regularly balanced, and the balance ought to be compared with the cash in hand, which should always tally with the statement of the balance, if the books and the cash have both been properly kept. The balance is found by summing up the paid *out* or Cr. (Creditor) column, and deducting that from the result of the summation of the paid *in*, Dr. (Debitor) side. The balance (if any) must, of course, agree with the cash in hand, for it is impossible to pay *out* more than has been got *in*. The cash-book is perfectly simple in its framework or ruling. There is (1) a space on the left-hand outside edge ruled off for the month in which the transactions take place, (2) another for the day of the month, (3) room for the insertion of the name of the person who has paid in any money (or on whose account it has been paid in), (4) spaces for the insertion of the exact sum so paid in, and (sometimes) (5) an inner set of money columns for the insertion of any discount which may have been allowed at payment. The ruling on the other side is precisely similar for month, day, person to whom or on whose account money has been paid out, sum, and (if requisite) discount. The sums are placed one under another on their respective sides of the folio, as they are received or paid, so that they may be readily cast up or summed prior to proceeding to balancing.

A posting column (when a *set* of books is kept) is also inserted in each side of the folio, to show into what folio of the ledger (or other similar book) each entry has been posted (or carried on for acknowledgment) to the *credit* or *debit*, as the case may be, of the payer or receiver. Cash ought to be balanced daily; and the calculation ought not to be left till the deficiency or error (if there should happen to be any) has been discovered. If it cannot be discovered when the whole details are likely to be fresh in the memory and easily revived, it is less likely to be found out when delay has intervened and made forgetfulness more possible.

FORM OF CASH-BOOK.

DR. CASH BOOK. CR.

Date.		Person by or for whom money has been paid in.	Posting Col.	Discount.			Cash		
1888.			No.	£	s.	D.	£	s.	D.
Aug.	3	To Balance—Cash in hand,					18	7	3
"	"	" John Rankine, . . .	39				41	3	4
"	"	" Shop Sales (Jas. Shiels),	17				7	12	8
"	"	" Warehouse Sales (Robt. Richards), . . .	22				402	3	10
"	"	" Peter French, . . .	86		3	2	16	8	5
"	"	" Wm. March, ...	218				3	2	9
"	"	" Archd. Merchant, . .	126	1	3	8	67	17	6
"	"	" Paterson & Isles, . .	162	1	1	2	85	15	2
"	"	" Jacobs & Steel, . . .	43				13	6	8
"	"	" Maxwelton & Archer, .	68		3	3	27	3	3
				[1]2	11	3	[2]683	0	10
		Discounts Balance Cr.,					[3]1	10	9
							[4]684	11	7

Date.		Persons to (or on whose account) money has been paid out.	Posting Col.	Discount.			Cash.		
1 88.			No.	£	s.	D.	£	s.	D.
Aug.		By Archibald Cousin's Bill (payable 41), . . .	16				297	18	6
"	"	" Williams & Orme, . .	301		18	2	63	5	4
"	"	" Simon Stevens, . . .	122				94	14	8
"	"	" Richard Bannatyne, .	48	3	1	2	77	16	2
"	"	" Insurance and Taxes, .	5				42	11	8
"	"	" James Peters, . . .	44		2	8	6	3	2
		" Carriage—E. & G. Railway, ...	5					7	3
				[1]4	2	0	[2]582	16	9
		Discounts Dr., . .		[3]2	11	3			
		Balance transferred to Dr.,		[4]1	10	9			
		" Balance—Cash in hand.					[5]101	14	10
							[6]684	11	7

[1] These are discounts paid out, and therefore are really Cr. entries.

[2] This is the summation of the column.

[3] Balance Cash in hand from Discounts.

[4] Total of Dr. entries. When the total of the Cr. entries have been deducted from this sum, the balance ought to give "cash in hand."

*** The entries "shop sales" and "warehouse sales" are got from a till or sales book, in which cash received for goods sold is jotted down. Each salesman notes his sales. Duplicates of these notes are sent to the desk with the cash. The cashier should see that the cash in till tallies with the totals of these notes when he writes out his sales for the day.

[1] These are really discounts received, and are therefore Dr. entries.

[2] Summation of column.

[3] These Cr. entries deducted from the Dr. ones leave

[4] The Balance cash in hand from Discounts.

[5] The summation of Credit entries £582 16*s.* 9*d.* leaves, when deducted from £684 11*s.* 7*d.*, this cash in hand.

[6] Cash in hand and sums paid out balance the Dr. entries.

*** "Carriage" would either be found in a petty-expense book, in which notes are taken of all small payments made in the course of trade, or on an accounts file.

The above transactions might be exhibited more simply in the following form of Cash-book Accounts.

			Out—Cr.			In—Dr.		
			£	s.	d.	£	s.	d.
Aug.	3	To Balance—Cash in hand,				18	7	3
"	"	" John Rankine, ...				41	3	4
"	"	" Shop Sales (Jas. Shiels),				7	12	8
"	"	" Warehouse Sales (Robert Richards), ...				402	3	10
"	"	By Arch. Cousins Bill (payable 41), ...	297	18	6			
"	"	" Williams & Orme, . .	63	5	4			
"	"	To " " Disct., .					18	2
"	"	" Peter French, ...				16	8	5
"	"	By " " Disct., . .		3	2			
"	"	" Simon Stevens, . . .	94	14	8			
"	"	To William March, . . .				3	2	9
"	"	By Richard Bannatyne, . .	77	16	2			
"	"	To " " Disct.,				3	1	2
"	"	By Insurance and Taxes, .	42	11	8			
"	"	To Arch. Merchant, . . .				67	17	6
"	"	By " " . . .	1	3	8			
"	"	" James Peters, ...	6	3	2			
"	"	To " " Disct., .					2	8
"	"	" Paterson & Isles, . .				85	15	2
"	"	By " " .	1	1	2			
"	"	To Jacobs & Steel, . . .				13	6	8
"	"	" Maxwelton & Archer, .				27	3	3
"	"	By " " .		3	3			
"	"	" Carriage (E. & G. Railway)		7	3			
			585	8	0	687	2	10
		Balance—Cash in hand,	101	14	10			
			687	2	10	687	2	10

It is usual in business to transfer the balances of the cash-book entries into the ledger at stated periods—prior to which time all the different entries ought to be posted to the separate accounts with which they are concerned; and the cash being regularly handed over or banked, the cash-book ought to be initialed by the receiver, or have the date and page of the bank-book noted on the margin.

Exercise.—Suppose John Anderson, clerk to Messrs. Ormiston & Armadale, has been sent out to collect and pay the following accounts, and that he presented on his return a statement of his cash in the form No. 2, given above, (1) how would it appear, and what would be the amount of cash he should bring to the warehouse? Being required to enter the whole of these transactions in a regular cash-book form, like No. 1, (2) how would they then stand in the cash-book folio? Bring out the result as "Balance cash in hand."

Messrs. Ormiston & Armadale gave him £80 as a balance in hand to commence his day's progress. Of this he paid £37 9*s.* 2*d.* to John Cope & Co.; from George Glennings he received in payment of an account £21 11*s.* 5*d.* (on which he allowed £1 17*s.* of discount); from Robert Richardson he received £43 10*s.*, and to J. G. Gilmour he paid £23. Having several small accounts against James Dobson, amounting in all to £13 7*s.*, he presented them, and with deduction of 7*s.* as discount he received payment. He next paid to Messrs. Hunter & Holms £12 19*s.*, getting 13*s.* of discount, and Wm. Hardinge & Sons £9 5*s.* 8*d.*, receiving 3*s.* 8*d.* in discount. Proceeding to Messrs. Graham, Hampole, & Co., he received an account of £19 8*s.* 4*d.*, regarding as part of that an account due by Messrs. Ormiston & Armadale, his employers, amounting to £4 6*s.* 2*d.*, for which he received a receipt. His next duty was to receive payment of a bill for £37 16*s.* 10*d.*, due by William Ormonde, but of this he only got £17 16*s.* After paying Williams, Paterson, & Campbell a sum of £31 17*s.*, on which he got 15*s.* discount, he returned with his record of these various transactions, and was found to have cash in hand, £76 3*s.* 5*d.*

The student is recommended, first, to make a scroll-form of the above on slate or on paper in pencil, and to test, by revisal, its absolute accuracy; and second, to rule a folio, after the examples given above, and to engross the whole carefully thereon.

GEOMETRY.

INTRODUCTION.

The word *geometry*—derived from the Greek words *gē*, the earth, and *metreō*, to measure—in its earliest use signified the *measurement of land.* It has, since then, widely extended its meaning. It is now of far greater importance in aiding men of science to measure the immensities of space than the limited extents of earthly possessions. It is, in fact, the science of space. The object of its investigation is extension (1) of distance, (2) of surface, and (3) of capacity. The space investigated may be near at hand or in the remotest regions of the universe, but it is all alike brought within the scope of geometrical reasoning. Our ordinary experience informs us of things existing outside of ourselves, and makes us take for granted the existence of space. From the very earliest unfoldings of man's inquiring and speculative nature, the relations of extent in space have been understood with peculiar clearness and known with special distinctness. It has been customary to account Egypt the birthplace of geometrical science, and the annual inundations of the Nile have been regarded as forming the most probable cause of the invention and use of geometry. It is not to be forgotten, however, that the early Chaldean shepherds made a regular and long-continued series of investigations in astronomy, the Phœnicians were skilled in the navigation of the million-miled Mediterranean, and the Egyptians were distinguished in architecture—all of which are sciences based on geometrical principles—long prior to the birth of Sesostris or the date assigned by Herodotus to the origin of geometry.

In what are commonly considered the oldest nations among which intellectual culture was soonest developed, we find few traces of a knowledge of geometry. The Chinese had some practical capacity in mensuration, and some acquaintance with the properties of a right-angled triangle. Of Egyptian or Babylonian geometry there are no remains or records, and in the Jewish writings there is no trace of such a science having a place among their studies. It is the opinion of the best mathematicians that we owe the rudiments of the science of space to the Hindus. From them it is probable that the early Greek philosophers learned a little indirectly. Thales is said to have been the first teacher of geometry in Greece, and Pontus, on the authority of Eudemus, an immediate pupil of Aristotle's, assigns to him the discovery of four propositions. Pythagoras first distinctly gave a scientific form to the deductive reasonings of geometricians. After him numerous students of philosophy devoted attention to geometrical invention and discovery. Plato was the most thoroughgoing of the advocates of the study of the properties of space and time as abstract ideas. Plutarch attributes to him the saying "God ever geometrizes," and though in no extant writings of his are these words to be found, the phrase, perhaps in a conversational form, emphasizes one of his characteristic opinions. In the "Timæus" Plato asserts the divine origin of geometry, and that its principles are only truly revealed to god-beloved men; in the "Republic" he says it has to do with the ever-existent, not the perishable; and in the "Epistle of Dion to Dionysius" he affirms that nothing can surpass the enthusiasm with which such recondite investigations are pursued by the nobler minds among men. His disciples and friends did much to make geometry more perfect. Other philosophic minds generalized many of the particular results of earlier research. Leo invented a method for deciding on the possibility or impossibility of a problem; Theudius composed an admirable treatise on the subject; Cyzicinus popularized it as a study in Athens; Hermotimus enlarged its scope; Philippus classified and arranged much that had been done before; but Euclid marshalled all previously attained geometrical knowledge into strict unity, and made it a gymnastic for the intellect.

Of Euclid's personal history very little is known. Even the place and date of his birth are unrecorded. He opened, at Alexandria, a mathematical school in the reign of the first Ptolemy (323–283 B.C.), and had that monarch's youngest son, Ptolemy Philadelphus, as a pupil and friend. His princely pupil sighed for a shorter method of acquiring the knowledge Euclid communicated, but he emphatically assured the mal

content that "there is no royal road to geometry." Among those who proceeded from his school were Eratosthenes, Archimedes, Apollonius, Theron, and many of the great Greek geometricians. Besides the well-known "Elements of Geometry," of which he was rather the compiler than the author, he furnished many other valuable treatises to mathematical literature. Among these were a preparatory outline on geometrical reasoning, a book of data, works on light, music, astronomy, conic sections, porisms, &c. On his "Elements," which for more than 2000 years have been the accepted groundwork of mathematical science, his fame mainly and securely rests. In them he collected the widely-scattered products of the ingenuity of his predecessors, formed them into a well-knit system of truths, notable for its excellence of plan, symmetry, and coherence. He is chargeable with prolixity and verbal repetitions; but these are probably due to his endeavour to make his book as like the explanatory discourses of a full-minded teacher as possible. Modern editors of the book have done much to improve it in brevity and clearness, and by the use of references, symbolic notation, &c., to avoid the diffuseness and verbiage of the original. They have now made Euclid's book remarkable for extreme precision of statement, explained how some of the assumptions which he made need no longer be assumed but may be readily proved, pruned its redundancies, and given definiteness and completeness to many of his statements and views. They have not been able to improve, however, upon his admirable power of deriving conclusions from premises and exemplifying clearly the elements and method of demonstrative reasoning. On this account, though many endeavours have been made to supersede Euclid's Elements, they remain to this day, as Dr. Whewell says, the standard work on the subject, and "his system is preferable," as Professor De Morgan expresses it, "to any system which has been proposed to supply its place." Not only, therefore, on account of its own intrinsic merits, but also on these two grounds, noted by Isaac Todhunter—viz. that "in England, the text-book of geometry consists of the elements of geometry," and that "nearly every official programme of instruction or of examination explicitly contains some portion of this work"—we intend to supply in our course considerable help to the understanding of this notable text-book.

There are, indeed, few subjects of study so favourable for self-instruction as geometry, and fewer still which can be made productive (or helpful towards the attainment) of more important practical results. It requires no elaborate apparatus or extensive library. A little paper, a few pens, a round ruler, perhaps a T-square, a pair of compasses, and a parallel ruler complete the absolutely necessary equipment. A clear head, a settled purpose, a persevering will, and capacity of returning again and again to the study of a problem or the overcoming of a difficulty, are all the student really needs to succeed in unravelling the entire mysteries not of Euclid only, but of the whole circle of those sciences which depend upon geometrical reasoning.

GEOMETRY—CHAPTER I.

DEFINITIONS, GEOMETRICAL TECHNICALITIES EXPLAINED—POSTULATES, AXIOMS, &c.

ALL visible and tangible objects occupy space. They are all capable of undergoing, or liable to, change, variation, or alteration. These changes may occur in (1) number, (2) magnitude, and (3) form. All forms and magnitudes have (separating) boundaries or surfaces. These have differences of parts, which receive the names, in common speech, of corners, edges, and outlines, and in geometrical language of angles, lines, and surfaces. Corners (or *angles*) are always found where edges (or *lines*) meet; and edges (or lines) where outlines (*surfaces* or *superficies*) meet. Corners terminate meeting lines, meeting lines terminate surfaces, surfaces terminate or bound solid bodies and inclose them. Surfaces constitute their form. There can be no visible or tangible, *i.e.* distinguishable solid, without boundaries; but the boundaries may be imagined or thought of by themselves, that is, as emptied of all solidity and contents. Ideas of forms, out of or from which all notion of solid content has been taken, are called *abstract*. In this abstract way of being thought of, (1) a *solid* is a space extended in length, breadth, and depth or thickness; (2) a *plane* is a surface (*superficies*) extended in length and breadth, but having no depth; (3) a *line* is the boundary of a superficies in one direction, and (4) a *point* is the termination of a line. Were a plane supposed to possess any thickness, or third dimension, it would really be a solid. We must think of it only as a mere imaginary superficial *flat*, an ideal space of simple extension. For example, a table is a solid form, having real boundaries, presenting to the eye, or the touch, real surfaces, lines, points, angles, &c.; if, however, the table be removed from its place, we can still, in imagination, figure to ourselves the space it occupied, the form it presented, the surface by which it was bounded, the lines which inclosed them, the angles in which they met, and the points thus formed. These representative and ideal occupants of space are mathematical or geometrical solids, planes, superficies, lines, points, angles, &c. *Real* points, &c., cannot be made, drawn, or represented on paper or any even surface; for, so to be made visible or tangible, they must have breadth, or real extension, however minute, while mathematical ones have none.

Plato's statement of the fact that geometricians "assume by way of materials, . . . figures, three kinds of angles, and other similar *data*," is quite as explicit as need be, or indeed can be. "These things," he says ("Republic," par. 510), "they are supposed to know, and having adopted them as hypotheses they decline to give any account of them, either to themselves or to others, on the assumption that they are self-evident; and, making these their starting-point, they proceed to travel through the remainder of the subject, and arrive at last, with perfect unanimity, at that which they have proposed as the object of investigation. They summon to their aid visible forms, and discourse about them, though their thoughts are busy, not with these forms, but with their originals; and though they discourse not with a view to the particular square and diameter which they draw, but with a view to the absolute square and the absolute diameter, and so on; for while they employ—by way of images—those figures and diagrams aforesaid, . . . they are really endeavouring to behold those abstractions which a person can only see with the eye of thought." In his "Seventh Epistle," that to the friends of Dion, he expounds the difference between a diagram and a mental conception of a circle, and illustrates this by referring to the most admirable specimen of the art of the turner as quite inadequate to realize the fine rotundity of the ideal. The ideal falls within the domain of the intellect, and its perfectness can in practice only be partially imitated by the faculty of sight, or the reproductive efforts of art. Geometry does not require to affirm the actual existence in nature of circle or triangle. As Hume said, "Even though no circle or triangle existed in nature, the statements of geometry would still be true." It is on this account that geometry is usually spoken of as an *abstract* science—one, that is, which has removed, as far as possible, from the ideas it entertains and deals with, every element of experience likely to distract its operations, and fixes its entire attention on those special ideas which are implicitly contained in all that we can experience here. That it is most distinctly also a real science, is made abundantly clear from the fact that all its deductions, demonstrations, &c., when applied to actual circles, triangles, cylinders, cones, &c., are found to be true of them, and there is no connection more close and thorough than that between theoretical and practical geometry.

The readiest way, perhaps, to secure to oneself the nearest practical approach to the idea of a mathematical superficies or plane is to take two pieces of flat-ground or polished glass, as perfectly coincident as possible, to place them together so that their surfaces shall meet each other everywhere on the side at which they are laid together and adjoin. The surface which lies between these adjoining pieces of glass will form a plane superficies, and a line supposed to run between these pieces in any direction upon that plane superficies would be a geometrical line, and its ends or its intersections with any other lines would form points.

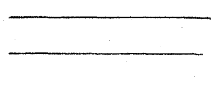
I. Definitions.—In geometry we require to accept the following *definitions*—which either (1) furnish us with an exact idea of the thing defined, (2) supply cautions against inaccuracies of thought, (3) impose restrictions on the mind to lessen vagueness of imagining, and so (4) provide a trustworthy groundwork for all the conclusions which may be come to regarding anything thus precisely set or brought before the mind.

1. A *point* is that which has (or marks) position, but no magnitude or parts. A visible or tangible point would be, in fact is, a *mathematical* surface.

2. A *line* is length without breadth, *i.e.* a succession of points lying evenly between any two points. The extremities of lines are points, and so are the intersections of one line with another.

3. A *right* or *straight line* is one in which each of and all the successive points lie in the same direction (and on the same plane). Parallel straight lines are such lines as, however far continued, can never meet. It has been suggested

Straight Line.



Parallel Lines.

that a better definition than this would be—Parallel straight lines are such as do each form right angles with one and the same perpendicular straight line. Playfair employs this axiomatic form—Two straight lines which cut one another are not both of them parallel to a third straight line.

Geometrical straight lines may be (1) *horizontal*, *i.e.* perfectly level, like the surface of water at rest; (2) *vertical* or perpendicular, *i.e.* quite upright—so as to form adjacent right angles with a horizontal line; or (3) *oblique*, neither horizontal nor vertical.

A *curved* line continually changes its direction, and is in no part of its extent straight. Curved lines are of "infinite variety." If a curved line is cut by a straight one in any two points, it is *concave* towards that side upon which the straight line lies, and *convex* towards the other side. A surface of which no part is plane is said to be curved.

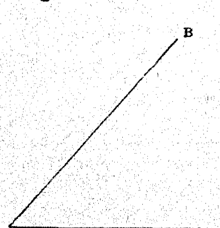
4. A *superficies* (or surface) is that which has extension (*i.e.* length and breadth) without thickness. The extremities of surfaces are lines.

5. A *plane* (or plane surface) is an extent of surface of such a kind that if any two points in it are taken, any straight line which would join them would lie wholly in that surface. Three points not in the same straight line are required to fix the position of a plane.

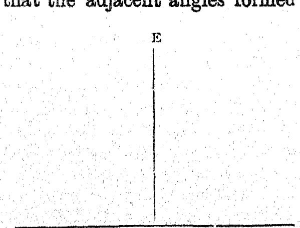
6. A plane *rectilineal* (right-lined) *angle* is the meeting point of two straight lines in the same plane, but not together forming one straight line, as A and D.

These lines are said to contain the angle or to make an angle with each other. The point where the two lines meet is called the *vertex* of the angle (as A and D), and the meeting lines its *arms*. If there is only one angle at a point it may be denoted by one letter, as A; but if there is more than one angle we require to indicate both arms and vertex, as A D E or E D F.

7. A *right angle* is one formed by the meeting of two straight lines in such a way that the adjacent angles formed



Angle.

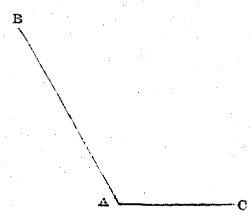


Right Angle.

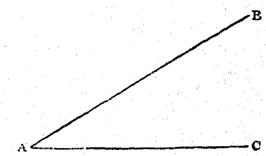
at the meeting point of one line with another which is perpendicular to it are equal to each other. Thus A D E and E D F are equal to one another; hence each of them is a right angle, and the line E is perpendicular to A D, while A D and D F are each perpendicular to D E.

8. An *obtuse angle* is one greater than a right angle.

9. An *acute angle* is one less than a right angle



Obtuse Angle.

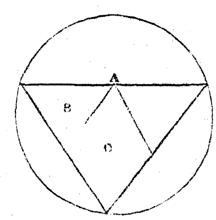


Acute Angle,

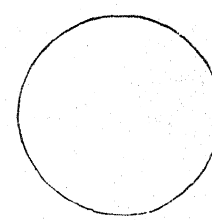
10. A *term* or *boundary* is the containing limit or the extremity of anything.

11. A *figure* is that which is inclosed by one or more boundaries; and the space inclosed within a figure is called its *area;* as A, circle; B, triangle; C, rhomboid.

12. A *circle* is a plane figure contained within (*i.e.* bounded by) one line which is called the circumference (or periphery).



Figure



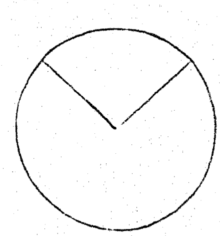
Circumference.

which is such that all straight lines drawn from that circumference to their meeting point within the figure are equal to one another. A *curved line* is one which, like the circumference, continually changes its direction between its extremities. Dr. William Whewell suggests that the following axiom and definition should take the place of the usual definition of a *circle*, viz.—"*Axiom.* If a line be so drawn as to be at every point equally distant from a certain point, this line will return into itself, or will be one line including a space. *Definition*—The space [inclosed] is called a *circle*, the line the *circumference*, and the point the centre." ("Philosophy of the Inductive Sciences," vol. i. p. 108.)

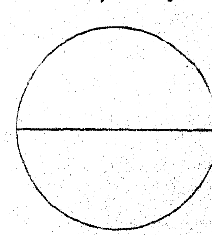
13. The *centre* of a circle is the meeting point at which all straight lines drawn from or to the circumference are equal. These equal lines are called the *radii* of a circle.

Concentric circles are those which have a common centre. Curved lines may be parallel, and are so when they are such that if their circles were completed they would be concentric.

14. A *diameter* is the double of a radius, *i.e.* any straight



Radii, Arc, and Sector.



Diameter and Semicircles.

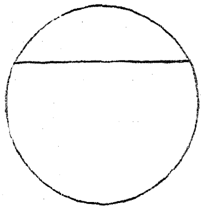
line passing through the centre and terminating at each extremity in the circumference of a circle.

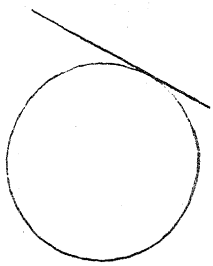
15. A *semicircle* is the figure bounded by a diameter and that part of the circumference which it meets and joins.

A *segment* is that figure or part of a circle which is contained within any straight line and that part of the circumference which it meets and joins.

An *arc* is any portion of a circumference.

A *chord* is any straight line—not passing through the centre—drawn across a circle.


Chord and Segment.

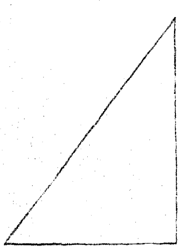

Tangent.

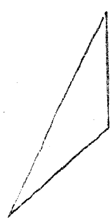
A *sector* is a portion of a circle inclosed by an arc and two radii.

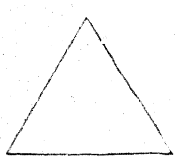
A *tangent* is a straight line drawn outside of a circle, which just touches the circumference, but does not cut off any part of a circle. The point at which it touches the circle is called the *point of contact.*

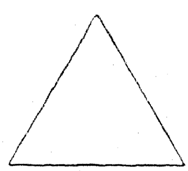
16. *Rectilineal figures* are those which are bounded by straight lines.

17. *Triangles*, or trilateral figures, are bounded by three straight lines. Triangles are generally divided (1) according to their angles into (*a*) *Right-angled*, which have one right

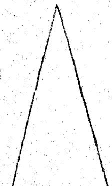

Right-angled Triangle.


Obtuse-angled Triangle.


Acute-angled Triangle.


Equilateral Triangle.

angle, as indeed they cannot have more; (*b*) *obtuse-angled*, which have an obtuse angle, in which case they cannot have a right angle; (*c*) *acute-angled*, which have all their angles acute; and (2) according to their sides, as (*a*) *Equilateral*, which have all their sides equal; (*b*) *isosceles* or equicrural, of

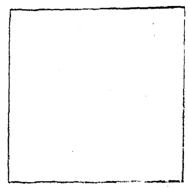

Isosceles Triangle.

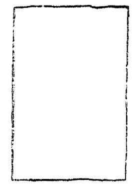

Scalene Triangle.

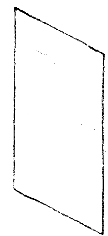
which two sides are equal; (*c*) *scalene* or irregular, all of whose sides are unequal.

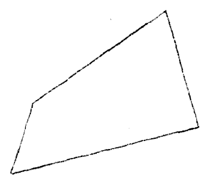
These *six* definitions of triangles are not co-exclusive. A right-angled triangle *must* be either (1) an isosceles or (2) a scalene triangle; an obtuse-angled triangle must also be either (1) an isosceles or (2) a scalene triangle; while an acute-angled triangle may be (1) an equilateral, (2) an isosceles, or (3) a scalene triangle.

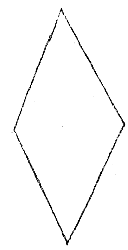
18. *Quadrilateral figures* are bounded by four straight lines. When such a figure has all its sides equal, and all its angles right angles, it is a *square;* when its opposite sides


Square.


Rectangle.


Rhomboid.


Trapezium.


Rhombus or Lozenge.

are parallel, it is a *parallelogram;* a parallelogram with right angles is a *rectangle*, and with no right angles a *rhomboid.* If the sides of a rhomboid are unequal, it is a *trapezium;* if equal, a *lozenge* or *rhombus.*

The *diagonals of a quadrilateral* are the lines which join its opposite angles.

19. *Multilateral figures* or polygons are rectilinear figures having more than four sides. Pentagons, hexagons, heptagons, octagons, &c., are the names given to figures having respectively five, six, seven, eight, &c., angles.

II. Technical Terms Explained.—Some of the technical terms used in geometry may now advantageously be explained. A *definition* is a brief characteristic description of a thing, such as shall serve to mark it off and distinguish it from all other things of the same sort. A *postulate* is a statement regarded as so self-evident that it does not require to be proved, but is taken for granted. An *axiom* is a statement so plain that it is seen to be true as soon as it is definitely expressed. A *proposition* is something set before the mind (1) to be done, as a *problem;* (2) to be proved, as a *theorem.* A *hypothesis* is a supposition made in the working out of a proposition. An *enunciation* is the statement of a proposition, setting forth, in general terms, the conditions of the problem or theorem, and what has to be done or proved. The *data* are the things allowed to be taken for granted or done. The *quæsita* are the things sought for in the problem or by the theorem. The *exposition* or particular enunciation is the restatement of the enunciation no longer in general terms, but in the especial reference to the means to be taken to work or prove it, *i.e.* to the particular figure which is to be considered. *Construction* is the special form of procedure, *i.e.* the straight lines, circles, angles, &c., requiring to be drawn in order that a proposition may be wrought out or demonstrated. *Demonstration* is the process by which it is proved that the solution reached is sound, or that the conclusion deduced is correct, *i.e.* in accordance with geometrical principles. It is a connected series of reasoning from *data*, *i.e.* truths admitted to be obvious before commencing, or truths already established. The *conclusion* is the result arrived at when a course of reasoning is finished. It is usual to put the letters Q.E.F. for *Quod erat faciendum*, "which was to be done," at the conclusion of a problem, and Q.E.D. *Quod erat demonstrandum*, "which was to be proved," at the conclusion of a *theorem.* Demonstration is either *direct* or *indirect.* The former shows that the very thing stated is proved to be true; the latter shows that all other cases (or conditions) except one are not capable of being proved to be

true, or have been palpably shown to be false, and hence the inference is made that the only one left is that alone which can be true. A *corollary* is an inference deduced directly from a (proved) proposition. A *scholium* (plural *scholia*) is a note, comment, or explanatory remark. A *lemma* is a preparatory proposition borrowed from some other part of the matter treated of, and introduced for the purpose of establishing or inferring thence some more important proposition.

When a *line* is said to be "given," it is its position only, and not its length, that is meant. When a line is said to be *finite*, it is a fixed length of line that is signified. The *base* of a figure is that side on which it appears to stand, though each side, in turn, as the position of the figure is (supposed to be) turned, may become the base. The *vertex* is the top or highest angular point of a figure. As in the case of the base, each angle may in turn become or be named the vertical angle. The *subtend* of an angle is the line stretching across opposite to the angle. The *hypothenuse* is the subtend of a right angle. The *perpendicular* of a line is one that forms a right angle at its point of junction with that line. The *altitude* of a figure is the perpendicular distance from the side or angle opposite the base to the base itself—or the base produced. A *diagonal* is a line joining two angular points. A *complement* is so much as is required to make up the difference between an acute angle and a right angle. A *supplement* is what is required to make an angle equal to two right angles. *Area* (of a figure) is the quantity of the surface it contains. *Loci*, in plane geometry, are straight lines or plane curves of which every single point (and none but these) satisfy the conditions of a problem.

III. Postulates.—The definitions assume that straight lines and circles may (possibly) exist. The postulates (Latin *postulo*, I ask leave to do) take for granted the possibility of representing to the mind these straight lines and circles, and claim the right of drawing and describing that visibly which can be imagined mentally. They are the essential principles of construction, the *minima* of things requiring to be allowed in the processes of proof to be employed in geometrical reasoning. These postulates are :—

1. A straight line may be drawn from any one point to any other point.
2. A terminated straight line may be produced to any length in a straight line.

Euclid did not fix the unit of magnitude, either of a straight line, angle, or superficies.

These two postulates confer the right to use a *ruler*, but not a *scale*.

3. A circle may be described from any centre at any distance from that centre.

This permits the use of a pair of compasses in describing the circle, but only from the point which forms the extremity of one straight line, as *the* centre, with that same line given in position and magnitude for *the* radius, at the extremity of which the circle is to be described.

Euclid employed other three postulates, but modern editors, regarding them as inferences, place them among the axioms, as x., xi., and xii.

IV. Axioms.—Axioms (Greek *axioma*, worthy of [credence]) are self-evident statements—seen and assented to as soon as made—incapable of any proof except a direct reference to experience, and therefore assumed as the basis of geometrical reasoning. The axioms are :—

I. Things which are equal to the same thing are equal to one another.

II. If equals be added to equals the wholes are equal.

III. If equals be taken from equals the remainders are equal.

IV. If equals be added to unequals the wholes are unequal.

V. If equals be taken from unequals the remainders are unequal.

VI. Things which are double of the same are equal to one another.

VII. Things which are halves of the same are equal to one another.

The seven preceding axioms were called by the early geometricians "common notions." They are not peculiar to the subject of geometry, and are quite as applicable to numerical as to geometrical magnitudes. The following five axioms are peculiarly axioms of geometry as they relate especially to magnitude.

VIII. Magnitudes which coincide with one another (that is, which exactly fill the same space) are equal.

This is the principle of *superposition*, viz. if all the parts and boundaries of any one figure, when they fall (or are placed) upon any other figure, cover and coincide with all the parts and boundaries of the latter figure, such figures are equal. When this superposition is actually performed, it furnishes the evidence of the senses; when it is conceived to be performed, it yields demonstration to the reason.

IX. The whole is greater than its part (and conversely the part is less than its whole).

X. Two straight lines cannot inclose a space.

XI. All right angles are equal to one another.

XII. If a straight line meets two straight lines, so as to make the two interior angles on the same side of it, taken together, less than two right angles, these two straight lines being continually produced shall at length meet upon that side on which the angles are less than two right angles.

Or, "Two straight lines which" (can, may, or do) "intersect one another cannot be both parallel to the same straight line."—*Playfair*.

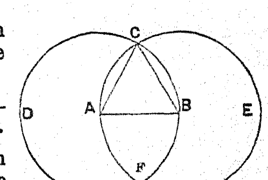
No fewer than *thirty* methods of overcoming the difficulty of securing axiomatic self-evidence to this statement have been proposed. They are summarized in the Appendix to Colonel Perronet Thompson's work on "Geometry without Axioms." Professor Robert Potts prefers the idea of equidistance contained in the following terms:—"Parallel lines are such as lie in the same plane, and which neither recede from nor approach to each other."

Students are earnestly advised to acquire a thorough knowledge of these definitions *before* proceeding to work any of the problems or theorems; and, while working these, to compare carefully every definition with the parts of construction which depend on them.

Euclid—Book I., Proposition 1.

Problem.—To describe an equilateral triangle upon a given finite straight line. The *datum* or thing given here is —, a finite straight line. The *quæsitum* or thing *sought* is, to describe an equilateral triangle on that given line. Our *postulates* are that a straight line may be drawn from any one point to any other point (1), and that a circle may be described from any centre at any distance from that centre (3). *Definition* 16 informs us what an equilateral triangle is, definition 11 what a circle is, while points and extremities are defined in 1 and 3. *Axiom* I. assures us that things which are equal to one and the same thing are equal to one another. Thus we are furnished with all the elements requisite for (1) construction and (2) solution. We now proceed step by step with the working out of the problem thus:—

1. Let A B be the given straight line (*datum*).
2. It is required to describe an equilateral triangle upon A B (*quæsitum*).
3. From the point A, with A B as radius, describe the circle B C D.



This is the first act of construction, and is founded on postulate 3.

4. From the point B, with B A as radius, describe the circle A C E.

This is the second act of construction, and has the same basis as the first, which it merely repeats.

5. From one of the points C, where the circles cut one another (or intersect), draw the straight lines C A, C B, joining the points A and B.

This postulate 1 permits us to do.

[It is here, it will be noticed, *taken for granted* that the two circles so described not only *may*, but *must* intersect one another. This would require us to have present in our minds the following proposition:—*If the circumference of two circles pass each through the centre of the other, they must cut (or divide) each other, and their*

circumferences must intersect each other. Euclid proves (Book III., Proposition x.) that in such circumstances there cannot be more than *two* points of intersection; but the general fact of necessary intersection, at least in one point, is enough for us here, and is palpable to sight—for we cannot make these circles (under the conditions) without the intersection being made.]

6. The figure A B C shall be an equilateral triangle (solution).

We have next to prove that our construction is justified, which we do step by step thus:—

7. Because the point A is the centre of the circle B C D, A C is equal to A B. By definition 13.

8. Because the point B is the centre of the circle A C E, B C is equal to A B. Also by definition 13.

9. Now it has already been proved (by 7) that A C is equal to A B.

10. Therefore A C and B C are each of them equal to A B (7 and 8).

11. But (by Axiom I.) "things which are equal to the same thing are equal to one another." Therefore A C is equal to B C.

12. Wherefore A B, B C, and C A are each of them equal to one another.

13. And they form the [constructed] triangle A B C.

14. The triangle A B C is therefore (1) equilateral,

15. And (2) it is described upon the given finite straight line A B, which was required to be done [Q.E.F.]

Exercise 1.—Go through the same process, drawing the straight lines from the point of intersection, F, to A and B.

Abbreviated form of stating Problem I.—From the points A and B respectively as centres, with the radii A B and B A, describe the two circles, intersecting each other, A C E, B C D, and join C A, C B. Because C A, C B are each of them equal to A B (as radii of circles, definition 13), they are equal to one another (by Axiom I.), and they form the equilateral triangle A B C, described on the line A B, which was required to be done.

This proposition may be even more condensed by the use of the symbols—$\odot$, circle; $\triangle$, an equilateral triangle; =, equal to; $\therefore$, therefore.

Let A B = *datum*. On it describe $\triangle$. From centre A, with A B as radius, describe $\odot$ B C D (3 post.), and from centre B, with radius B A, describe $\odot$ A C D. From C, where $\odot$s A C D, B C D intersect, draw C A, A B (1 post.), $\therefore$ A B C is $\triangle$. For A B = A C and B A = B C, being both radii of $\odot$s B C D, A C D (I ax.) Q.E F.

Exercise 2.—Write out similarly the problem, working it from the point F.

Exercise 3.—Construct two equilateral triangles upon a given straight line, *e.g.* A B.

The problem solved in Proposition 1 is now to be made useful in the production of a practical result. We have learned to describe an equilateral triangle upon a given finite straight line. We are now to apply this acquisition to the accomplishment of something else. If we are asked to make a straight line in a position fixed for us by having one of its extremities, *i.e.* a point given to us to proceed from, and were required to make that straight line equal to another straight line, also given to us, how could we proceed to fulfil our task? Proposition 1 puts it in our power to manage the manipulation of it according to the conditions. We can easily get the required straight line practically if we, by taking a pair of compasses and measuring off the length of the given line, apply these compasses to the given point, and describe the line to the length required as the compasses indicate. But in geometrical construction everything must be carried on rigorously, step by step, in an unexceptionably demonstrative system. We seek first, therefore, the most distinct statement of the task assigned to us. This is supplied in:—

Euclid—Book I., Proposition 2.

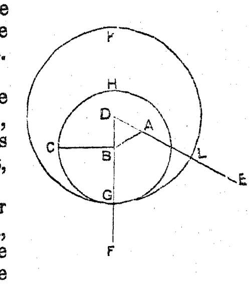
From a given point to draw a straight line equal to a given finite straight line.

This, we see, is a *problem*. It sets before us something to be *done*. We arrange the *data*.

1. Let A be the given point and B C the given finite straight line. Next we ought to set clearly before our minds the *quæsitum*.

2. It is required to draw from the point A a straight line equal to B C. We proceed now to the work of constructing, taking postulate 1 as our authority, and we

3. Draw from the point A to B (one extremity of the given finite straight line B C) the straight line A B. And, as we have learned to do by Prop. 1, we



4. Describe upon it (A B) the equilateral triangle D A B, Prop. 1. Having secured thus the lines D A, D B, we next, authorized by post. 2,

5. Produce (*i.e.* lengthen or extend) the straight lines D A, D B to E and F. We have by this means gained a finite (though indefinite) straight line, passing through (and having as part of it) the point B, and we can now have that point as a centre and B C as a radius. This makes the next step possible.

6. From the point B, with distance (or radius) B C, describe the circle C G H (post. 3), meeting and cutting the line D F at G. Turning our attention next to the line A L, which includes in it the given point A, we

7. From the centre D at the distance (or with the radius D G), describe the circle G K L. This is authorized, as before, by post. 3; and the process just completed enables us, as we shall shortly see, with perfect certainty to assert

8. A L is equal to B C (*solution*). We know this must be the case so soon as we reflect—

9. Because the point B is the centre of the circle C G H, B G is equal to B C, for they are radii of the same circle.

Reasoning on the same ground (def. 13), we can add—

10. And because the point D is the centre of the circle G K L, D L is equal to D G. Here we have quite plainly found that D L and D G are equals, and we know—for by our own previously stated act of construction (described at 4) we made them so—that

11. The parts of them, D A and D B, are equal. Because by def. 17 and Prop. 1 they are the sides of an equilateral triangle, Ax. III. warrants us in asserting,

12. Hence the remainder A L is equal to the remainder B G.

13. But B G is equal to B C, and therefore A L is equal to B C.

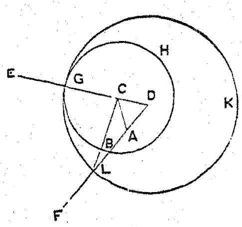
14. Wherefore, from the "given point" A a straight line, A L, has been drawn, equal to the given straight line B C, which was to be done [Q.E.F.]

As a mere matter of fact we saw that this operation could be performed easily with a pair of compasses. It might also be accepted as a geometrical possibility, by allowing that, under postulate 3, a straight line or a circle may be removed from any one place to any other without change of its magnitude; or if we were to alter our postulate 3 to this, let it be granted that a circle may be described from any point as centre, and with a radius equal to any finite distance.

It is quite evident that Euclid has not exhausted all the possible methods of this problem. An innumerable series of lines, each equal to B C, could be drawn from the point A. We see that (1) the given line B C has two extremities, to each of which a straight line might be drawn from the point A; (2) that the equilateral triangle may be formed on either side of the straight line so drawn; and (3) the side B D of the triangle may be produced either way. Of course, also, the given point might have been *in* the given straight line B C, or it might have been either of the extremities of the line B C.

If the student observes carefully the following general instructions for the construction of the requisite figures, he will be able to work out all the possible forms of the problem:—(1) Join the given point with either extremity of the given right line; (2) on either side of the line which joins them construct an equilateral triangle; (3) take that extremity of the given straight line which has been joined with the given

point as centre; (4) from that, with the given line as distance, describe a circle; (5) produce to the circumference of that circle the side of the equilateral triangle which terminates at the given line, but not at the given point; (6) with that extremity of the same side which is remote from the given line as centre, with the distance from that point at which being produced it meets the circumference, describe another circle; (7) produce to its circumference that side of the triangle which terminates at the given point, not at the given line, either through its centre or in the opposite direction, according as the previously drawn line was produced; and (8) the line lying between the given point and the circumference of the circle last described will be the required line. The annexed figure will show one method of solving the question differently, and may suggest the other possibilities to the patient and persevering. These may safely be left to exercise the inventive ingenuity of the student, as they involve no real difficulty; although, to avoid discouraging the diligent worker labouring to get eight different lines in his eight different solutions, we may mention that it is possible that—if the point A becomes a part of B C when produced—some of the solutions may coincide. This depends upon a property of equilateral triangles which Euclid points out in Book I. Prop. 32.



BOTANY—CHAPTER I.

INTRODUCTORY OBSERVATIONS AND DEFINITIONS.

THE works of creation are generally considered as forming three great divisions, popularly styled the three kingdoms of Nature—the animal, the vegetable, and the mineral. Superficial observers are apt to think that these are separated from one another by a sufficiently broad line of demarcation. If, however, we look closely into them, we shall find that there are but two great divisions in the eye of the philosopher—the *organic* and the *inorganic*. The most prominent distinction between the material objects which surround us is derived from their possessing, or being destitute of, an *organized* structure; their having, or not having, *organs* fitted for carrying on certain *functions*. The want of organization characterizes mere inert matter, and affords an evidence of the absence of a living principle. On the other hand, the slightest trace of organization discovered in any natural object is a proof that life *is*, or at least *was once*, present in that object.

The separate particles of which unorganized bodies are composed are either (1) *elementary atoms*, or (2) *compound molecules*, in which certain elementary atoms are united together by chemical affinity, in definite proportions. Thus a bit of the shining calcareous spar of which chimney-piece ornaments are made consists of many molecules, or minute grains, united together into a mass. Each of these molecules again, however small it may be, consists of an atom of lime united to an atom of carbonic acid; and in the hands of the chemist these two constituents can be disunited and exhibited separately, by the aid of simple processes and appliances. When these molecules are permitted to become solid, after having been melted by heat or dissolved in some powerful acid, they arrange themselves into various regular mathematical forms, called crystals. These crystals can increase in size only by the addition of new matter *to their outside;* they do not *grow* or increase *from within*. When peculiar circumstances do not permit the component particles to arrange themselves into crystals, they combine into shapeless masses, possessing the same chemical composition as if they had been crystallized. All such natural combinations of unorganized matter are called (*a*) simple minerals; and (*b*) compound minerals are just heterogeneous mixtures of fragments of simple minerals (as granite of mingled pieces of quartz, mica, and felspar). Of those simple and compound minerals the earth which we inhabit is composed.

Organized bodies are made up of the same elementary constituents as those which compose unorganized bodies, but not in the same proportions, nor exactly in the same combinations. They are, however, completely and satisfactorily distinguished from the latter, by the presence of a living principle within them, and by the manner in which they increase. Their chemical constituents are not united so that their composition is homogeneous throughout, like that of simple minerals; nor do they form various composite grains which are irregularly jumbled together, as in compound minerals, but are arranged so as to form a number of *organs*, or parts which are fitted to carry on certain actions or perform certain functions which are necessary for the life of the individual. The increase of organized bodies is not produced by the addition merely of new particles to their outsides, but by a process of *growth*. This growth takes place by the deposition of new particles among the old; and this addition of new particles to others like them already in the body, is called *assimilation* (Latin, "making like"). Assimilation is carried on by the nourishing particles passing into certain cavities in the inside of the living body, or tubes called *vessels* running through them, by which they are carried and put where they are wanted, and become alive. Thus, the food taken into the stomach of an animal becomes converted into blood; the blood is carried through the bloodvessels into all parts of the body, and is deposited where it is required: where bone is wanted, it becomes bone; where flesh is wanted, it becomes flesh; where skin is needed, it becomes skin.

This process of assimilation depends on that mysterious principle which we call *life*. Life is something quite different from any of the forces to which inorganic bodies are subject; and it is capable of controlling, and to a certain extent of counteracting, the effect of these forces. The most striking peculiarity in vital force, or the power of life, is its varying intensity at different times, so that at one time the functions of the living body are maintained in full vigour, and at another carried on with languor; and its decrease at a certain period of existence, so that the creature in which it resides shall cease to grow, shall decay, and finally cease to live, the constituents of its body becoming decomposed, to unite again in new forms, and contribute to the growth again of new creatures.

The organized division of nature comprises two kingdoms, (1) the *animal*, and (2) the *vegetable*. Daily observation is sufficient to satisfy us of the propriety of such a division. Yet it is extremely difficult, and has hitherto baffled all the attempts of naturalists, to mark off precisely their boundaries. No definitions of a *plant* and an *animal* have yet been found sufficiently precise to indicate all the conditions under which different organized bodies are found; for even to this day there are some species of which scientists are yet in doubt under which kingdom they should be arranged. The most constant, if not quite a universal distinction, and one which all can understand, between animals and vegetables is, that the former alone are provided with internal cavities or *stomachs*, into which their food is taken to be digested before it is fitted for effective assimilation.

Among the higher classes of each kingdom, indeed, there is no difficulty in pointing out the line of demarcation; but as we descend in the scale we find an increasing similarity in external characteristics. In addition to the living principle, *sensibility* may be considered a most marked property of an animal. That is an endowment by which an individual is rendered conscious of its existence and its wants, and by which it is induced to seek to satisfy these wants by some functions depending on its will.

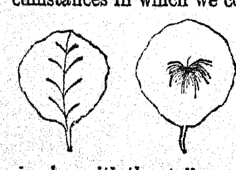
Botany is the science of plant life. There are thousands upon thousands of different kinds of plants. Many lift their heads high in air, throw out spreading branches, and have these laden with autumn fruits. Others are so minute, so small and delicate, that we can only see them aright through a microscope. Between these extremes there are multitudes of intermediate sizes. Some grow on land, others in the water, a number of them even being denizens of the sea. Of all these botany asks, what are the phenomena of their life? of what are they composed? how are they constructed? what are the circumstances of their being and growth? in what

countries are they found? what sort of places do they inhabit? what are their characteristics? what beauty and charm mark each? what are their uses? by what properties are they distinguished for good or evil to man or animal? through what processes do they pass from seed to fruit? how are they cultivated? to what uses can they be put? how long do they endure? Such are some of the inquiries which the curiosity of man induces him to make, and to which the botanist endeavours to supply satisfactory answers, as the results of his research. Few studies are more pleasant and instructive; few so well calculated to quicken thought and sharpen observation, to induce method and improve the discriminative faculties. Besides being so attractive in its matter, it is commended to us all the more on this account, that its objects are always with us in their infinite variety, and therefore afford us constantly recurring opportunities—might we not almost say plentiful yet innocent temptations—to consider the flowers of the field how they grow, the trees of the forest in what fashions they develop, the lichen and the moss with what elegancy they clothe the rock and boulder.

Botany may be regarded as embracing every inquiry which can be made into the various phenomena of the vegetable kingdom. These inquiries may have three different aims: (1) the investigation of the outward forms and conditions in which plants are met; (2) the examination of the various functions which they perform while in life; and (3) the discovery of the laws by which their distribution over the earth's surface is regulated. For practical purposes the results of these inquiries may be conveniently arranged under two heads. The one may be called Descriptive Botany. It includes the examination, description, and classification of all the circumstances connected with the external figure and internal structure of plants. While engaged in this division of the science, we consider vegetable products much in the same way as we would study the component parts of some complicated machine, of whose several portions we must have some knowledge separately before we can expect to understand how they work together, or appreciate the purposes which each is intended to subserve. The other department may be named Physiological Botany. In it we consider these machines as if in action—investigate the phenomena produced upon the machinery by the moving power, which is the living principle. In fact, we trace the plants which we select for our study, from their origin by seed, through their growth, to their fructification and their withering and decay.

This separation of the anatomy from the physiology of plants looks well in laying down a system; but it is found best in practice to conjoin them, so as, after describing their parts, to proceed to explain their uses. Care will be taken in our course to explain the structure of the various parts of plants in a natural order, so that the uses of one set of parts having been fully unfolded, will naturally lead to the description of the set which are next called into play in the growth and life of the vegetable.

In all descriptive sciences, as anatomy, chemistry, mineralogy, and botany, there is a series of *descriptive terms*, i.e. *ordinary words* which have not the same latitude of signification that they have in common speech, and *peculiar words* expressing special forms or qualities, which we are not led, perhaps, to remark particularly in the cursory view which we take of the objects to which they refer, in the ordinary circumstances in which we come in contact with them. Each of these terms has a strictly limited technical signification, so that when we meet it we know *exactly* what it denotes; *e.g.* the words *round* and *orbicular* in common language have the same meaning, but in botany a *round* leaf is circular, with the stalk at the edge, while an *orbicular* one has its stalk inserted at or near its centre. When, therefore, we meet the word *orbicular* in the description of any plant, we know so exactly the form of leaf indicated that we cannot mistake it for any other.



The practical student gradually acquires a technical *glossary*, that is, a collection of terms having special meanings, which by and by he transfers to his memory.

For no other science has there been formed a *glossology*—as De Candolle calls it, or a *terminology*, as we usually name a collection of technical words—so precisely descriptive and so felicitously skilful and appropriate as botany possesses. Each part of a plant has been distinctively named, and the form of each part, however minute, has had a large number of specific terms set apart to describe it. By this means the botanist can convey or receive a knowledge of the form and structure of a plant as exact as if each minute part of it was presented to him, not only in reality, but as if largely magnified. The terminology or peculiar vocabulary of a classificatory science, when the sense of its terms is known and fixed—that is, when the same word always expresses the same idea, and the same idea is always expressed by the same word—imparts clearness and precision to the whole science. It at once phonographs and photographs what is spoken of. The *flower* has been successively discriminated into the *calyx*, the *corolla*, the *stamens*, and the *pistils*. The sections of the outer whorl of a flower were named *sepals* by the Flemish botanist N. J. Necker (1729-93); those of the corolla or inner whorl were called *petals* by Columna. *Perianth* was used to denote both calyx and corolla, whether one or both are present or are so blended that they cannot be easily distinguished in the floral envelope. Erhart and De Candolle use for this the term *perigone*. The part in which the grain, fruit, nut, pod (as it may be) is, is called the *pericarp*. By descriptive terms, distinctly defined and definitely combined, such as these are, the language of botany is exquisitely suggestive and singularly simple when once thoroughly known.

Of course, the rude pre-scientific, if not unscientific, nomenclature and classification of plants into trees, shrubs, and herbs, while useful enough in their own day and way, are too indefinite and deficient in character to be of service, except in every-day speech. Even the division of plants made by Dioscorides into aromatic, esculent, medicinal, and vinous, though long popular, is now felt to be insufficient to express what we have learned of vegetable life, forms, and character. Though no attempt to confine the infinite variety of nature within the narrow bounds of any possible nomenclature or definition is likely to be permanently successful, yet the invention and use of a well-chosen mark for or definition of any actual phenomena in—or object of—nature helps to keep our minds attentive to its peculiarities, and to recall them to our memories. We cannot too strongly commend the botanical student to acquire with care an exact acquaintance with the technical terms of the science and their meanings; they contain locked up in them treasures of wisdom and right-thinking. He will find himself greatly helped to this knowledge by the numerous carefully drawn Plates accompanying and illustrating these lessons.

The pleasant intimacy with nature into which botany brings us gives it a great charm. "Every plant of the field before it was in the earth, and every herb of the field before it grew" was formed for a purpose, on a plan, and with its own special nature. Ever since man knew them he has been indebted to them and curious about them. They have furnished food both for body and mind. They have given joy and been made an object of care. Not only have cereals and fruits received culture, but flowers have been tended and loved. Forests, fruit, and ornamental trees, flowers and aromatic plants, shrubs and herbs, corn, wheat, and grass, orchards, vineyards, and gardens are mentioned in Scripture, and Solomon, in his God-given wisdom, "spoke of trees, from the cedar tree that is in Lebanon even unto the hyssop (*Capparis spinosa*) that springeth out of the wall." Homer mentions the gardens of Alcinous and the vineyards of Laertes, and tells us of Lycaon pruning figs in the orchard of his father Priam. Among the *Rhizotomoi* or root-cutters of Greece, who used their knowledge in making magical charms, there must have been considerable acquaintance with those plants in which "poison hath residence and medicine power." Aristotle probably founded botanical science, for his knowledge of vegetable physiology was wide and wonderful. His successor Theophrastus bestowed much attention on the organs, tissues, and properties of plants. From the Greek and Roman poets we gather that a considerable amount of accurate knowledge of the habits of plants was diffused

among them, and through them was communicated to their readers. In later times botany was mainly studied as an auxiliary to magic and medicine. The Arabian herbalists passed on their knowledge to the monks. At the close of the middle ages, Sprengel calculates that about 1400 species of plants were known to the botanists of that time. Cuba's "Hortus Sanitatis" (Garden of Health, 1485) was the first work on natural history illustrated with woodcuts. In 1532 Otho Brunsfels, a Bernese physician, began a reformation in botanical science. His "Herbarum Vivæ Icones" (Living Likenesses of Plants) excited enthusiasm. Leo Fuchs (1501-65), in whose honour the *Fuchsia* is named, taught the reformed botany in Tübingen. In his "Commentaries on Dioscorides" (1544), P. A. Matthiolus, of Sienna, collected all the medico-botanical knowledge of his age. Conrad Gesner unfortunately died (1565) before his collection for a general history of plants was published. For this he had above 1500 drawings prepared, and he first suggested that the true nature of the distinctions of plants should be sought in their organs of reproduction rather than in those of nutrition. This originated systematic botany. Charles d'Ecluse (Clusius) introduced neatness, exactitude, precision, and method into botanical descriptions and experiments. The botanical gardens of Vienna and of Leyden, while under his care, became famous for their classification, excellence, and adaptation to instruction. J. Junge, of Lübeck, aided the movement for clearness of definition and accuracy of description. J. A. Cortusi, director of the Botanic Gardens of Padua, and author of a work on "The Simples of Padua;" W. Turner, of Morpeth; Rembert Dodonæus, of Holland; A. Cæsalpinus, the Aristotelian of Arezzo; and the two Bauhins (Jean and Gaspard) of Amiens, followed up Gesner's idea, and were the most famous students of vegetable life in the sixteenth century.

Matthew Lobel (1558–1616), a native of Lille, but resident in England in Elizabeth's time, who published his "Plantarum Historia" (History of Plants) at Antwerp in 1576, has had his name renowned by Linnæus as the designator of the genus Lobelia. He first devised the method of arranging plants in their natural order, and several of his combinations are acknowledged even now by writers on systematic botany. Gerard's "Herbal" (1597) was in his day the standard book on botany in England. It was mainly an adaptation of Dodonæus, unskilfully redacted, with Lobel's classification, and with a careless reproduction of the plates of J. T. Tabernæmontanus' "New Complete Herbal," which had been edited in a second edition (1590) by Nicolas Bruner after the author's death in 1588.

A new departure in botanical research was taken by the use of the microscope in the examination of the elementary organs of plants. Henshaw, in 1661, discovered by its aid the spiral vessels or elastic coils of fibres running from end to end of the stem-structure, and shortly afterwards Hooke, by the same instrument, examined the cellular tissue. Grew, in his "Anatomy of Vegetables," communicated his researches in physiological botany. He was the demonstrator of the functions of stamens and pistils, and the discoverer of the difference between monocotyledonous and dicotyledonous seeds. Malpighi also investigated microscopically the structure of vegetables, and made many valuable contributions to our knowledge of plant-life. Following the pathway of experimental observation thus suggested, John Ray, in his "Historia Plantarum" (1686), not only cleared up many points in the structure and functions of plants, but set forth a philosophy of classification. A. Q. Rivinus, in his "Introductio ad rem Herbariam," P. Magnol (after whom Plumier named the beautiful American magnolia trees), in his "Prodromus Historiæ Generalis Plantarum," and J. P. de Tournefort, famous both as a traveller and a botanist, in his "Institutiones rei Herbariæ," proposed other systems of classification, founded not on physiological principles, like that of Ray, but on the outward differences in the corolla of plants. After them arose Linnæus, the revolutionizer of botany. He was a genius, vigorous in thought, rigorous in logic, precise in speech, patient in well-doing. He was the inventor of the most terse and lucid technical nomenclature which, up to that time, the world had ever seen. The neatness and accuracy of his distinctive definitions were unrivalled, and he seems to have been esteemed as one who had caught Protean nature in a verbal net at last. Antoine L. de Jussieu, a disciple of Ray, produced in 1789 his "Genera Plantarum," in which, adapting the simple and accurate language of Linnæus to actual scientific requirements, while adopting the principles of Ray and the fundamental distinctions of Tournefort, he produced an arrangement of plants more nearly in accordance with their natural relations than that of any previous system. He replaced verbal by vital botany. Patrick Brown and A. P. De Candolle followed Jussieu, and improved as well as extended the systematics of plant-life. To Albert van Haller we also owe much as a philosophic promoter of botany—mainly, however, on lines opposed to those of Linnæus.

Another era dawned upon botanical studies when Goethe, with a poet's fine sense of analogies, issued his "Metamorphoses of Plants," and structural botany took, on the basis of his suggestion, the precision of science. His idea was that all the organs, which have so many functions to perform and so many names applied to them, are in fact only one organ modified. The type-form is the leaf; the *bract* is a contracted leaf, the first modification of a common leaf towards a change into the floral organs; the *calyx* is a combination of several leaves forming an external envelope for the flower; the *corolla* is a union of several other leaves, coloured, and forming the second envelope of the flower; the stamens are contracted and coloured leaves, with the pulp that connects the veins of leaves in the condition of powder; the pistils, another arrangement of leaves, rolled up and combined for a scientific purpose. Goethe's views have influenced the minds of students of vegetable physiology much.

The Hedwigs of Austria, father and son, who devoted themselves assiduously to the physiology of cryptogamic plants; Devaux, who established at Bayeux a fine botanic garden, and along with La Galissonière did much for the culture of magnolias; J. Gaertner, of St. Petersburg, whose work on "Carpologia" made valuable suggestions; L. C. Richard, editor of Bulliard's "Botanic Dictionary," carried on the science in its practical progress and theoretical amendments; and F. C. Medikus pursued the study of structural botany with good results. By their labours, physiological, descriptive, and practical botany were cultivated with zeal and made advantageous to human welfare.

The modern progress of botany has for the most part consisted in efforts to substantiate, modify, and consolidate the principles of the science; to work out the details into a consummate whole; and to arrange in lucid order the facts which accumulate so rapidly now-a-days concerning the plant-life of the globe. Among its more illustrious cultivators have been the unfortunate Stephen L. Endlicher; Adolphe T. Brongniart, most famous in fossil botany; Robert Brown, whom Humboldt described as "the chief of botanists;" K. F. Meisner, of Basle; K. F. Martius, of Munich; John Lindley, professor of botany in University College, London; Sir William J. Hooker, and his highly distinguished descendants, whose names are written on almost every page of modern botanical discovery. Researches in vegetable physiology of noteworthy importance have been made by H. F. Link and F. J. Meyen, of Berlin; Hugo von Mohl, of Tübingen; and M. J. Schleidan, of Jena, who opposed the views of Baron Liebig on organic chemistry in its application to vegetable physiology. To these might be added J. G. Macvicar, the expounder of the morphology of plants; Leo H. Grindon, who has placed botanical studies before the public in a lovably popular manner, yet embued with a thoughtful felicity of exposition; Daniel Oliver, William Carruthers, J. H. Balfour, and many others in Britain, who have supplied well-digested summaries of the essentials of botany. Along with these, also, we might name Luerssen, Prantl, Sachs, &c., who have illuminated the science abroad with clear statement, apt illustration, and philosophic views. Besides these there are numerous professors of the science in many universities, and men of mark connected with innumerable botanical societies, metropolitan and provincial, whose labours deserve honourable mention, though space forbids our now extending this notice by special references to the mass of fine expository papers which the Transactions of many botanical associations are constantly accumulating—all proofs of the

living interest which this particular branch of the study of nature awakens in intellectual circles.

Flora was the name given by the Romans to the goddess of flowers; and her name is now used to indicate a book containing a systematic botanical description of the plants of a particular country. Thus we have a Flora Britannica, containing descriptions of all the plants which are natives of Great Britain; a Flora Laponica, describing all the plants in Lapland; a Flora Americana, telling us about the plants in America; and on a smaller scale several local floras.

A flora is arranged like a dictionary, and you search in it till you find a description corresponding to the specimen you want to know about; and thus you ascertain its name, its connections, its localities, its habits, and its uses. Although the various kinds of plants are so many, that above 2400 species of flowering plants are enumerated as natives of Britain, there is no difficulty in finding out most of them, after having got grounded in the meaning of botanical terms, and somewhat practised in the mode of using them.

But after having examined a plant, and ascertained its name, qualities, &c., it is often desirable to preserve it, so that it can be referred to at a future time. A good specimen ought to be selected, laid in a natural position between sheets of soft gray paper, placed between two boards, and subjected to pressure. The paper should be changed daily, until the plant has become quite dry and stiff. It may then be fixed on a sheet of paper, on which is written its name, the place where it was gathered, with the date, and any other memoranda that may be thought of. When these accumulate, they can readily be arranged in families, &c. A collection made in this way is called a *herbarium* or *hortus siccus* (dry garden).

As a means of improving and exercising the natural faculties of observation, of training the mind to inductive reasoning, of widening and quickening the sympathy and taste, botany has established its character. It stimulates the activities of the senses, it brings the mind into direct contact with nature in all the bounteous fulness of her glorious variousness, supplies a fund of easily carried knowledge, excites many happy emotions, and amidst a pleasant open-air deliciousness, it nourishes the intellect. It needs no costly apparatus to commence with. In the highways and the byeways, in the meadows and the hedgerows, by runnel or brook, in glen or glade, on mountain-slope or sea-margin, in the clefts of the rock or the crevices of ruined walls, in garden or field, in marsh-waste or forest, at home or abroad, the varied and beautiful life of the vegetable kingdom is to be found. Indoor the fern-case or the flower-stand may keep the spirit awake to the mystery of plant life, and out of doors the weed is precious as a lesson book, and the flowers are full of the exquisite joy of wisdom. The moss, green as an emerald, grows on the field-dyke, the foxglove's purple cup enlivens the hillside, the small blue eye of the "forget-me-not" peeps out at us from the quietest nooks, the daisy—"wee modest crimson-tipped flower"—decks the village green and decorates the river-bank, the dell is "all golden with the never bloomless furze," "the pansy freaked with jet" hides under the hawthorn or the holly, the flexile woodbine spreads its cream-coloured whorls of flowers along the pathway fence, while, as Crabbe says,

> "In every chink the fern delights to grow,
> With glossy leaf and tawny bloom below."

We have just to begin, examine, grow interested, and become wise. The pursuit passes into pleasure, and the study steadies the mind. Order, plan, purpose, and beauty; fragrance, grace, utility, and attractiveness inform and delight us. Common things as they are, plants supply and induce uncommon wisdom and the most innocent gladness. Besides the ease with which it can be studied, the readiness with which materials for pursuing it may be found, and the healthy and exhilarating nature of the employment it affords, botany supplies a most excellent intellectual training. It is characterized as a classificatory science by the excellence of its terminology and the distinctness of its nomenclature. The names of plants are nearly all derived from the Greek, and are the most tersely expressive that have ever been invented. They are models of philosophical precision. Systematic thought must be indicated by and incorporated into a systematic set of names. The sign and the thing (or thought) signified must thus be made one. As the Latin line has it—

> "Nomina si nescis, perit et cognitio rerum."
> (If the names of things thou knowest not, even the knowledge of them perishes.)

It is essential to clearness of exposition, and even to accuracy of thought, that science should have a systematical, compact, appropriate, and complete vocabulary. Then the whole aggregate of knowledge which it has systematized is capable of being put and kept before the mind as a science. The excellent system of Cæsalpinus failed to influence scientific botany as it ought, because its phraseology was not moulded into simple and precise expressions. When, at length, botany gained an articulate and wisely-planned vocabulary, it took its place in the hierarchy of the sciences.

In 1738, the celebrated Linnæus, professor of physic at Upsal, in Sweden, published his famous work on Botany. It created the science at once. Previous to his time botany was a mere list of plants, with some not very accurate descriptions of their external appearance. His powerful mind —of which the distinguishing characteristic was the capacity for generalization—saw that as all plants are alive, and have the power of producing successors, a ground for scientific classification was quite attainable.

Linnæus remarked that in plants, as in animals, there is a distinction of sexes, into male and female—the females being those in which the seeds of the young progeny appear, and on which the care of producing and nourishing them devolves until they are capable of independent existence. In a large proportion of plants, the males and females can be discriminated from one another; and of these plants, he formed a great division, which he called *Phanerogamous*, from two Greek words signifying a conspicuous marriage. This includes Flowering plants. In the remaining division of plants, the germs which are to form the young appear in a different manner; there is no obvious mark which would lead us to call one male and another female; and hence he called this division *Cryptogamous*, from the Greek word signifying a concealed marriage, and this division contains the Flowerless plants—such as ferns, mosses, sea-weeds, and lichens.

THE GERMAN LANGUAGE.—CHAPTER I.

ITS ALPHABET AND PRONUNCIATION.

GERMANY is "the laboratory of thought;" and hence the German language, as Leibnitz said, "seems to be the daughter of philosophy." Those who wish to study German as a discipline will find in it an excellent means of exercising, strengthening, and enlarging the powers of the mind. The commercial and political importance of Germany among the nations is making itself felt in all lands, and those who would hold rank among the merchant-craft or the social powers of their age and time, require to attain a competent knowledge of the master-tongue of the Continent. German life is developing in every form, and German therefore is gaining greater power and influence and interest in many lands and in many relations. German literature is the most active, productive, and progressive in Europe, and the scholars of Germany are the pioneer students of the world. In theology, medicine, philology, philosophy, applied science, education, and erudition, the great currents of thought are all *set* by influences originating in that land of industry, enterprise, thoughtfulness, and thoroughness. All these vital considerations tend to make the study of German a duty and a necessity.

A notion prevails somewhat widely that German is a difficult language to learn. This is very far from being the case, if we once get over the obstacle of using and realizing a new alphabet. That implies but a slight amount of observation and application. A very large number of the etymological roots of the German language are quite similar to our own, and are therefore familiar to our minds. The methods of derivation and composition are for the most part uniform and easily understood. The ordinary prefixes and affixes are

readily learned and employed; while nearly 20,000 words collected from classical sources and incorporated with but slight alterations into the language of England as well as of Germany, supply a considerably large vocabulary, which one may almost say is common to both languages. These are no insignificant helps towards the acquisition of a knowledge of German.

The real difficulties in the study of a foreign language, as they suggest themselves to the mind, are (1) the large demand made on the memory to acquire a new vocabulary; (2) the care necessary to conjoin the proper meaning to each word when seen, heard, or thought of; (3) the committing to memory of the inflexions of a complex language, and attending to all the intricate *minutiæ* of their regulations and exceptions; (4) the acquirement of a facility in placing the words in the syntactic order proper to the language being learnt; and (5) the express indispensability of gaining a knowledge of idiomatic phrases and specific exceptions, inwrought with the associations of those who habitually use them, but hard to be retained when these associations themselves need to be made matters of study.

It is easy to place this list of difficulties before our eyes in small compass, and when we see them thus all at once before us, we are naturally inclined to shrink from encountering them. But though we can, in imagination, take them all into our thoughts as a multitude, we must in actual practice engage with them only in detail. The vocabulary does not require to be all learned and known before we can begin to read, write, or speak. Indeed the entire vocabulary of any language—least of all a living one—is seldom known to any one in all its terms, variations, and peculiarities. There is always a large part of every vocabulary of utility only to experts and specialists. The usual vocabulary of ordinary men is not extensive, and even that we acquire by degrees as we go on, not all at once. Experience and usage, as well as the frequency with which words and phrases recur to memory and are repeated in speech, aid greatly in facilitating the correct conjoining of meaning and word. As to inflexions and conjugations—though they all require to be set forth in systematic order—a large proportion of those which are most taxing on the memory and understanding occur seldom and exceptionally, and so need not trouble the student much in his early progress; or they are so commonly in use as to secure recognition and observance almost involuntarily.

The construction of sentences in every language depends on the special nature of men's habits of thought; but habits of speech also affect their manner of thinking; and so powerful are human associations that we seldom recall to memory the words of any language without remembering something of the collocations they assume. Men very soon, while acquiring a language, have to think in that language, and in that way its collocations come easily into the mind—even when the syntax which rules them is not present in all our thoughts. Habit is a great helper. Idioms and peculiarities, just because they are so, are likely to impress the mind and dwell in the memory permanently, and by constancy of recurrence soon acquire the familiarity which arises from use. To the thoughtful mind there is therefore no great cause for hopelessness in entering upon a course of studies in a foreign tongue. It is evident that with earnestness and care no ordinarily endowed mind need hesitate to devote himself to such a study through fear of failure. To get begun is almost always the worst part of an undertaking.

To begin at the beginning we must, of course, set our minds to the acquisition of some knowledge of the pronunciation of the language we are about to study. A few general remarks on the elements of all articulate speech-sounds may help us the more readily to apply the knowledge of the production of vocal sounds which we have, to the comprehending of the more specific pronunciation or system of alphabetic sounds which distinguishes the German language.

Man, either imitating sounds heard from other creatures, or naturally feeling within himself the power of producing sounds, developed the capacity of speech, and has, out of a few primitive elementary changes made by slight movements of the vocal organs, constructed a simple, powerful, and expressive representation of thought by words, words which are made up of syllables, and syllables which are made up of letters—letters capable of being arranged in order as an *alphabet*.

The alphabet used in Germany is most generally known as Gothic. As the earliest printed books imitated the contemporary writing, and the first use of printing types was made in Germany and the Netherlands, the books, which are the delight of bibliomaniacs and book-hunters, are what are called "black letter," *i.e.* are printed in this Gothic character. What are known as the Roman characters were used very generally between the fifth and the twelfth centuries. The Gothic then began to prevail, and at the introduction of printing acquired predominance, till in the sixteenth century Aldus Manutius endeavoured to introduce the Venetian or Aldine, now known as the Italic alphabet. This came only into exceptional use, and Roman characters at length carried the day. The Germans, however, adhered to their own system of typography, and continue to use the Gothic alphabet—though of late many of the authors and several of the publishers of Germany have commenced to use Roman characters in their books. The movement thus begun may perhaps lead to the supercession of the Gothic type; but meanwhile the student of German requires to familiarize his eyes to the perception of this character, and will hereafter need to teach his hand to use a fresh form of penmanship. We may just now content ourselves with teaching and he with learning the Alphabet, which will be found on page 66.

The lungs, the throat, the mouth, the tongue, and the nose are the *organs* of articulate speech; aspiration, voice, and articulation are the *agents* employed in the production of speech-sounds. Aspiration is an intentionally strong breathing, which helps to impart force and effectiveness to vocal sounds. We perceive the difference when we produce the vowel sound *ah!* and the aspirated one *ha!* Voice is the tone resulting from the unimpeded passage of air through the organs of speech. Articulation is that series of changes in the position of the organs of speech required to produce distinct sounds. The immediate vowels are 𝔞, 𝔦, 𝔲; the intermediate, 𝔢 and 𝔬—the former having its origin between 𝔞 and 𝔦, the latter between 𝔦 and 𝔲. The vowels 𝔞, 𝔢, 𝔬, have a more perfect vocal character than 𝔦 and 𝔲, and are regarded as liquid or flowing vowels. This difference enables the liquid vowels to yield a much greater variety of delicate shades of sound than 𝔦 and 𝔲, the flexional or consonanted vowels. The immediate vowels recur in all languages, the intermediate in most. These five definite pure vocal sounds are expressed by those five simple letters employed in European languages for vowels, 𝔞, 𝔢, 𝔦, 𝔬, 𝔲. In German 𝔶 appears as a simple vowel in foreign words only, and then has the sound of 𝔦; it is never used, as in English, with a consonantal power. 𝔄, 𝔞, has the same sound as *a* in *far*, *are*, *papa*. 𝔈, 𝔢, has two different sounds: (1) long, as in *fare*, *fate;* (2) short, when followed by two consonants or a double one, or at the end of a word, or in an unaccented final syllable, as *e* in *get*. 𝔈, when doubled, is sounded *ay;* it is never sounded like *ee* in *sneer*. ℑ, 𝔦, is pronounced like *ee* in *feet*. 𝔒, 𝔬, resembles *o* in *so* and *bone*, or *oa* in *moan*, when long; and, when short, *ŏ* in *loss*. But *oo* is always long, like *o* in *those*. 𝔘, 𝔲, when long, has the sound of *oo* in *soon* or *u* in *rule;* when followed by two consonants, short, like terminal *u* in *useful*. If we arrange the vowels in the order of their issue from the vocal tube 𝔦, 𝔢, 𝔞, 𝔬, 𝔲, there can be formed six true diphthongs 𝔞𝔦, 𝔞𝔲, 𝔢𝔦, 𝔢𝔲, 𝔬𝔦, 𝔬𝔲. The imperfect diphthongs are any other combinations of the five original vowels, such as 𝔞𝔢, 𝔞𝔬, 𝔢𝔞, 𝔢𝔬, 𝔦𝔞, 𝔦𝔢, 𝔦𝔬, 𝔦𝔲, 𝔲𝔞, 𝔲𝔢, 𝔲𝔦, 𝔲𝔬. The first two of these form the links between the two classes, and might be called semi-perfects.

Of the foregoing six perfect diphthongs, German recognizes the following four, viz. 𝔈𝔦, 𝔢𝔦, like *y* in *my* or *i* in *mine;* 𝔄𝔦, 𝔞𝔦, has a slightly longer and more open sound, as *i* in *fire* or *y* in *sky;* 𝔄𝔲, 𝔞𝔲, as *ou* in *about*, *sound;* 𝔈𝔲, 𝔢𝔲, like *oi* in *point*, or *oy* in *boy*. Three pure vowels, 𝔞, 𝔬, 𝔲, are capable of being softened or modified by putting the letter 𝔢 after each if a capital, and by 𝔢 (or two little dots over each in writing) if it is a small letter. These modified vowels are pronounced as follows, viz., 𝔄𝔢, 𝔞̈, long, like *ai* in *fair;* short, like *e* in *were;* 𝔒𝔢, 𝔬̈, has no exact counterpart in the English language; it is like *eu* in the French word *seul*, and slightly

resembles *oo* in *spoon*, or *eu* in *Teuton* spoken shortly; Ue, ü, like *ue* in *due*, but less sharp and hard. The three vowels, a, e, o, may be doubled to indicate that they are long; i is lengthened by putting e after it; and all the vowels are long when h mute, belonging to the same syllable, follows them.

The organs engaged in the formation of articulate sounds act pair-wise in the production of consonants. One part is active, movable, and capable of exerting pressure on the other, which is passive, motionless, and impressionable. The under lip and the upper lip can move and compress. The tongue is mobile both in the frontal and the hinder part. The teeth, palate, and nostrils are, comparatively speaking, stationary. Consonants differ in their character according to the organs by which they are chiefly articulated and enunciated. Hence they are divided into *labials*, produced by the lips; *dentals*, by the teeth; *palatals*, by the palate; *nasals*, through the nose; and *gutturals*, in the throat. Consonants formed by the same kind of organic action may be considered as homogeneous and classified together as an aid to the proper understanding of them, and a help towards their proper articulation.

1. The aspirate h—being formed by the mere passage of the breath through the mouth—cannot be classed among consonantal articulations. It is either (1) silent, when following a vowel or the letter t in the same syllable; or (2) audible, and then pronounced as in English.

2. The sound of the mutes is momentary, the result of a sudden expulsion of the breath through the organs more or less brought into contact by articulation, and becoming audible when the breath passes through the articulated organs. Those letters which do not admit of free vocal intonation, fall naturally into three classes:

	Labials.	Linguals.	Gutturals.
I. Mutes, which are			
1. Soft,	b	d	g
2. Hard,	p	t	k
3. Aspirate,	v, pf		ch
II. Semivowels, or Liquids:			
1. Imperfect,	w	s	j=zhe
2. Perfect { Oral,		l	r
Nasal,	m	n	ng
III. Sibilants,	f	s, ss, c, ſch	chs

The consonants b, c, d, f, k, l, m, n, p, t, x, and z are pronounced as in English, except that b and d, when they end a word (or even a syllable) followed by another consonant, take a harder sound, somewhat liker p and t. K is never silent before n. In words ending in tion from the Latin, t sounds as ts.

G has the hard sound of English *g* in *guard*. When preceded by a, o, u, or au, at the end of a word or syllable, it sounds like Scotch *ch* in *loch*, *gh* in Irish *lough;* ng is pronounced as in *song*. In the unaccented final ig the pronunciation is *ich*.

J has the sound of *y* in *yet*, except in words derived from the French, when it retains the *sh* sound.

R is sounded fully and distinctly in all situations.

S is always hard and hissing, as in English *supper;* ſſ is harsher still.

Long ſ is placed at the beginning and in the middle, s only at the end, of syllables. If in a non-composed word there are two ſ one after another, they are written ſſ. Waſſer, *water;* wiſſen, *know;* müſſen, *must*.

V is pronounced like English *f*.

W resembles in sound the English and French *v*.

Z takes the sound of *ts* in *its*.

The double and compound consonants in German require considerable attention.

Ch, ch, when preceded by a, o, u, and au, resembles *ch* in the Scotch *loch*, or the Greek χ; when it follows e, i, ei, ä, ö, äu, eu, or ü, as well as after any consonant, it takes a less guttural and a more palatal sound, like *ough* in Old English *hough*, or *h* in *hollow*. As an initial it takes the sound of k, and when followed by s in the same syllable it is pronounced like x.

Ck in the middle and at the end of a word is similar to English *ck*. It never, however, follows a consonant in German. When a word having ck in the middle of it requires at the end of a line to be divided, it is resolved into kk, *e.g.* zucker undivided, zuk-ker divided.

Qu is exactly like English *qu* in *quell*, *quire*.

ſſ and ss has quite the sound of the double *s* in English *lass*, *less*, *loss*.

Tiarks says, "There is a great difference between ſſ and ß, the former being a double ſ with a double sound; the latter a sharp ſ, with the sound of the English *s* in *son*. As the double ſ (ſſ) can neither be sounded at the end of a word nor after t, the Germans in former times never used it in such a case, but employed ß instead. Some modern writers, however, retain the ſſ (for which a new type has been made) at the end of a word and before t, when the vowel in the syllable is short or acute: as, Faſs, cask; Haſs, hatred; Fluſs, river; muſs, muſst; goſs, haſst. They use ß at the end of words and before t, when the vowel in the syllable is long or broad, and after a diphthong: as, Spaß, joke; Gruß, greeting; Stoß, thrust; groß, great; ſpaßt, aßt; Fleiß, industry; außer, fließen, fleißig. Whenever any of the first-mentioned words, with a short or acute vowel, increases, the ſſ *must* be used: as Fäſſer, casks; haſſen, to hate; Flüſſe, rivers; müſſen, goſſen. But when those which have a long or broad vowel increase, the ß must be used: as, Späße, Grüße, Stöße, große. A simple final s must be used at the end of those words which require ſ only when they increase: as, Gras, grass, pl. Gräſer; Glas, glass, pl. Gläſer; Loos, lot, pl. Looſe."

Pf requires a closer compression of the lips than a simple p, like *pp* in *appeal*.

Sch is pronounced as in *shrift*, *childish*.

Sp and st have a little of the *h* sound introduced, as if *sh(ee)p* or *sh(ee)t* were articulated without their vowels.

Th only lengthens the preceding syllable when medial or terminal, and h is not sounded when th occurs at the beginning of a word.

Tz is the mode of representing a z doubled after a vowel; it never follows a consonant. It is pronounced like *ts* in *its*.

The pronunciation indicated in the table (on page 66), and in the remarks annexed to it, is, of course, given as only approximately correct. As the late Rev. J. G. Tiarks said: "It is almost impossible to teach the pronunciation of German by writing, without the assistance of the voice; for every language has peculiar sounds, to which nothing similar is to be found in another." In all countries there are varieties of tone and dialectic differences of pronunciation. These bear but an insignificant proportion, however, to the points on which substantial agreement exists, and it may comfort those who sigh, perhaps, with a vain regret that it is impossible by books to gain an absolutely accurate German pronunciation, to remember that even an actual residence in the country would not infallibly confer that confessedly inestimable boon. In one part of Germany sounds are appropriated to letters which are not used to represent them in another; and the teacher of German who has been born and educated in one part of the Fatherland would find minute differences in the value which he would assign to certain letters and that which would be assigned by one belonging to another part. We have done our best to place before our readers, in plain instructions, the nearest approach that can be made to a correct method of producing the sounds peculiar to German speech, and in regard to our endeavour we may quote again the words of the thoroughly competent Tiarks, with reference to the fact here stated:—"The pronunciation which we have endeavoured to indicate is that called die Hochdeutſche Sprache, *the High-German Language. The Low-German*, die Plattdeutſche Sprache, is spoken by the common people in the north of Germany. In several provinces in Germany where High-German is spoken as the language of the educated, the natives deviate from the proper pronunciation. The upper-Saxons, for instance, pronounce the three soft letters, b, d, g, like the hard p, t, k, and again, p like b. Baum they pronounce Paum, Dank—Tank, Gabe—Kabe, Pohlen—Bohlen. In the south of Germany, especially in that part formerly called Swabia, ſ is pronounced like ſch before t and p: as, Stunde, hour, is pronounced Schtunde; Spiel, play, Schpiel. In several provinces ü is pronounced like ie, eu like ei, ö like the broad e: so that no difference is perceptible in the pronunciation of Thür, door, and Thier, animal; heulen, to howl, and

heilen, to cure; die Bösen, the wicked, and die Besen, the brooms. The lower-Saxons omit the sound of ch after s, and so pronounce sneiden instead of schneiden, to cut; swer instead of schwer, difficult; they also sound d for t: as, Dag for Tag, day. In some parts of Germany, g is pronounced like *y* in *year*, or the German j in ja, yes: as, eine jebratene Jans und eine jesalzene Jurke ist eine jute Jabe Jottes, for eine gebratene Gans und eine gesalzene Gurke ist eine gute Gabe Gottes; that is, "a roasted goose and a salted cucumber is a good gift of God."

This is enough to show that, if the learner applies himself with due diligence and care to the instructions given, he will be able to acquire a power of speaking the German language not unlike that of a moderately well-educated native who may be unversed in the minor punctilios of pronunciation, but who can make his meaning known and his intentions plain.

Owing to the predominance of consonant sounds in the German language, it is perhaps more difficult than English to inspire its sentences with melodiousness. This, however, may be greatly aided by care in the selection of phrases and in the collocation of words. The frequency with which short unaccented syllables occur and recur constitutes another element tending to inharmoniousness of construction; but the difficulty arising from this source is greatly lessened by the expressiveness of the roots and stems of its vocables, and by the clear significancy of its prefixes and affixes. Both of these facts, again, give good ground for hopefulness in the toil of acquiring a fair pronunciation, for as every letter (except h in some cases) is sounded in German, an accurate acquaintance with the etymological elements of the language, which are really few and simple, supplies the ability to use the immense number of derivatives compounded out of these, with no further exercise of memory and thought than is requisite to master and retain the primary roots, stems, prefixes, and affixes, and the very few regulations concerning their composition to which they are subject. The oft-decried abstruse terminology of German is, in itself, not so full of inherent difficulty as many people imagine, while it has this valuable compensatory quality, that it secures for the language the power of being self-interpretative. It is true that German has been far too little elaborated as an instrument of conversational entertainment, and has not therefore been so much polished and simplified as some other languages of nations more demonstrative in their social relations. It is too bookish and literary, and therefore inflexible and systematic; but that is a defect which is rapidly being remedied in the freer and fresher life of the nation. Meanwhile the objection which may be predicated of the language in itself has no effect other than a favourable one as regards the learning of the language by a foreigner: for the latter must always gain most of his knowledge by the use of books, and the more bookish the language is in itself, the more easily may the mind be brought to use it.

Observe, however, particularly that in German every letter —with the exception of h in the middle or at the end of a syllable—is pronounced. There are (except h) no silent letters; therefore g and k before n, and p preceding s, require to be sounded in such words as Gnade, mercy; Knie, knee; and Psalm. This may be most easily got at by inserting the shortest vowel-sound of u between the two letters: Gŭna-dĕ, Kŭnee, Pŭsalm.

In German speech and reading, another peculiarity requires, perhaps, to be kept with distinct prominence before the mind; that is, that soft consonants do not form a proper euphonic close to a syllable. To avoid the occurrence of such a sound at the end of a syllable b is pronounced like p; d like t; g like ch or k; v like f; soft s is hardened into ß. But when, by declension or conjugation, words having their termination in such soft consonants take an additional syllable, the custom of hardening the sound loses its effect, and the soft sound is resumed. For instance, Lob, fame, is pronounced lōp, but Lobes, lō-bess; Laub, foliage, lowp; Laubes, low-bess; bald, soon, bălt; baldig, quickly, bal-dich, &c. Every vowel has a long and a short sound; but these sounds are precisely the same in pronunciation or tone, and differ only in length; *e.g.* Boden, ground-soil, bōden; Bollen, ball, bŏllen.

Vowels have their long sounds (1) when at the end of a syllable; (2) when h precedes or follows; (3) when doubled (which only occurs with a, e, and o); (4) often before a single consonant, especially if it is soft; (5) i is long when followed by e—as in Igel, hedgehog, eegĕl; Thal, dale, tal; Ihn (objective of Er), him, een; Aal, eel, āl; Seele, soul, say-lĕ; Boot, boat, bōt; Bad, bath, bād; Schaf, sheep, shāf; Sieb, sieve, zeep; lieben, to love, lee-ben.

Vowels have their short sounds before (1) a double consonant; (2) two consonants; and (3) a single consonant, especially when hard, or in a polysyllable, as in Tonne, cask, tŏn-nĕ; Storch, stork, stŏrch.

The Germans endeavour, by careful accentuation, to improve the euphony of their language. Not only do they impart to their sentences the rhetorical significance of emphasis, as in Der Knabe ist nicht erzogen sondern verzogen (The boy is not educated but miseducated), but they most studiously take care, by grammatical accent, to indicate the unity of the meaning of a sentence, as Ihr Oheim ist schon elf Jahre todt (Their uncle has been these eleven years *dead*). Over and above these they have the syllabic accent brought under very exact rule—*e.g.* gebet, give, gay'-bĕt; Gebet, prayer, gĕ-bayt'.

I. The main stress of the voice in pronunciation is put on the root or stem-syllable, as in Heilung, healing, hī'-loong; Heimlichkeit, secrecy, hīm'-lichkīt; Sänger, poet, seng'er, &c. But to this rule there are the following exceptions:—(1) German words to which foreign terminations have been attached —*e.g.* Blumist, florist, bloo-meest'; Glasur, glazing, gla-soor', &c.; (2) words introduced directly from foreign languages: Advocat, ădvŏ-cāt'; Baron, bă-rōn'; Musik, moo-seek'; (3) compound verbs, which have separate prefixes, have the accent always on the prefix, whereas in verbs compounded with the inseparable prefixes the accent is always on the verb—*e.g.* bei'fügen, to incline, bī'-foogen; los'reißen, to tear off, lōs'-rīsen; mitwirken, to co-operate, mĭt'veerken.

II. In compound words the first element, which, as a general rule, presents the chief idea and modifies the second one, gets the main stress of the voice laid on it, as dunkelblau, dark-blue, doon'kĕl-blow.

III. The prefixes be, ge, er, ver, zer, and the final syllables en, er, chen, kel, sel, ig, zig, are unaccented.

IV. Two unaccented syllables, each containing an e, cannot follow one another, unless it happen that the words cannot, if the elision be enforced, be pronounced without a hiatus; *e.g.* sammelen is transformed into sammeln or sammlen, collect; edeleren into edlern, more generous; but in such words as antwortete the elision cannot be made euphoniously.

In the dividing of words into syllables the pronunciation forms the main guide; but the following rules may be explicitly mentioned, viz.:—

1. In simple words, when a single consonant occurs between two vowels, that consonant is given to the second syllable—*e.g.* Lei=den, suffering; Sa=gen, to speak; Na=gel, nail.
2. When two consonants (not being compound letters, and the latter is not l or r) occur in the middle of a word, the first goes to the preceding and the second to the succeeding syllable—*e.g.* Er=ben, to inherit; Fel=sen, crags; Töp=fer, potter; Was=ser, water.
3. Ch, ck, and sch, when they occur between two vowels, the first of which is short, give their sound to each syllable—*e.g.* lachen, lach-chen; waschen, wasch-schen.
4. The component parts of compound words are pronounced separately—*e.g.* Frucht=korb, fruit-basket; Neun=stundig, consisting of nine hours, &c.

Prefixes, under this rule, also retain their own sound and syllabification, as bestreiten, bĕ-strī-ten, to combat; geirrt, gĕ-eert, strayed; beurkunden, bĕ-oor-koon-den, to authenticate.

We have prepared for the use of the student a tabular view, which places before him handily (on page 66) a concise yet complete vidimus of the alphabet, with notices of all the specialties in pronunciation requiring attention duly exemplified; and we commend to him a painstaking study of that page, for a familiar acquaintance with its contents will simplify and expedite his acquisition of a speaking power over the German tongue. It only remains to be said that accent is wholly different from quantity; but this matter will hereafter require further explanation, and hence only the most indispensable rules in reference to accent as affecting pronunciation have been here given.

TABLE OF THE GERMAN ALPHABET.

SHOWING THE NAMES AND SOUNDS OF THE LETTERS, WITH EXAMPLES.

Roman Character.	German Character.	German Name.	Initial Sound.	Final Sound.	Examples.
A a	𝔄 𝔞	ah	as *a* in far	as *a* in pa-pa	alt, old; da, since; Vater, father; Mann, man.
B b	𝔅 𝔟	bey	as *b* in bold	*p* in pulp, culprit	bald, soon; bold, bold; Gabe, gift; Laub, foliage.
C c	ℭ 𝔠	tsey	*s* before *e*, *i*, and *y*, as cell *k* before *a*, *o*, *u*, and *h*, as call		Centner, centre; Citrone, citron; Cypern, Cyprus. Carl, Charles; Concert, concert; Cultur, culture.
D d	𝔇 𝔡	dey	as *d* in dale	as *t* in tale, alter	Dank, thanks; Abend, evening; mild, mild.
E e	𝔈 𝔢	ey	as *ay* in pay as *ĕ* in shell	 as *e* in get, met	Mehl, meal; Ehre, honour; Esel, ass. Ende, end; Feld, field; Sterne, star; Titel, title.
F f	𝔉 𝔣	eff	as *f* in find, false		frei, free; faul, lazy; frisch, fresh; Fürst, prince.
G g	𝔊 𝔤	gay	as *g* in got	sometimes like a soft *ich*	Gott, God; Gift, poison; gut, good; gütig, kind.
H h	ℌ 𝔥	hah	as *h* in hollow	silent	Huld, favour; Hilfe, help; Kuh, cow.
I i	ℑ 𝔦	ee	as *ee* in meet		Inhalt, meaning; immer, always; vier, four.
J j	𝔍 𝔧	yot	as *y* in yarn		Jahr, year; Jammer, distress; jemand, somebody.
K k	𝔎 𝔨	kah	as *k* in kind		kam, came; Käse, cheese; Kaiser, emperor.
L l	𝔏 𝔩	ell	as *l* in leaf		Leben, life; Lehrer, teacher; Letter, type (letter).
M m	𝔐 𝔪	em	as *m* in man		Morgen, morning; Mutter, mother; Meer, sea.
N n	𝔑 𝔫	enn	as *n* in nine		Natur, nature; Neid, envy; niemand, nobody.
O o	𝔒 𝔬	o	as *ō* in stone as *ŏ* in off		Ohr, ear; Rose, rose; Hof, farmyard. kommen, come; Sorge, sorrow; Ochse, ox.
P p	𝔓 𝔭	pey	as *p* in pay		Pack, pack; Park, park; Pein, pain; Preis, price.
Q q	𝔔 𝔮	koo	as *k* in kind		Qual, pang; Quelle, source; Quirl, twirl.
R r	ℜ 𝔯	airr	as *r* in red		roth, red; Ruhm, renown; Rand, edge; Flur, floor.
S s	𝔖 ſ 𝔰	ess	as *s* in six	as *ss* in loss	Säbel, sabre; Hirse, millet-seed; sechs, six.
T t	𝔗 𝔱	tey	as *t* in tea		Tag, day; Taube, dove; Tisch, table; Tante, aunt.
U u	𝔘 𝔲	oo	as *oo* in soon		Uhu, owl; Ufer, shore; Uhr, clock; Hut, hat.
V v	𝔙 𝔳	fow	as *f* in father		Vater, father; Vetter, cousin; Vogel, bird.
W w	𝔚 𝔴	vey	as *v* in vine		Wald, wood; Wild, game; Wind, wind.
X x	𝔛 𝔵	iks	as *x* in exercise		Axt, axe; Hexe, witch; Taxe, tax (rate).
Y y	𝔜 𝔶	ypsilon	as *y* in yes		Yacht, yacht; York, York.
Z z	ℨ 𝔷	tset	as *ts* in its		Zahn, tooth; zehn, ten; Zeit, time; Zorn, rage
Ch ch	ℭ𝔥 𝔠𝔥		as *k* in kind	as *ch* in loch	Cholera, cholera; Loch, hole; Stachel, sting.
Chs chs	ℭ𝔥𝔰 𝔠𝔥𝔰			as *ks* or *x* in looks, box	Wachs, wax; sechs, six; Ochse, ox; Dachs, terrier.
Sch sch	𝔖𝔠𝔥 ſ𝔠𝔥		as *sh* in shot		Schule, school; Mensch, man; Schuh, shoe.
Ae ae	𝔄𝔢 𝔞̈		long, as *ay* in pay short, as *ĕ* in met		Fäden, thread; Bäden, baths; Mädchen, girl. Hände, hands; Fälle, cases; Sänger, singer.
Oe oe	𝔒𝔢 𝔬̈		as between *ew* in stew and *oo* in spoon		öde, waste; Höhle, cavity; Oefen, oven.
Ue ue	𝔘𝔢 𝔲̈		as *oo* in moon, but sharper		müde, tired; hüten, guard; pünktlich, punctually.
Ai ai	𝔄𝔦 𝔞𝔦		as *ī* in fire		Waise, orphan; Kaiser, Cæsar; Hain, grove.
Au au	𝔄𝔲 𝔞𝔲		as *ow* in now		Haus, house; Baum, tree; Raum, room.
Aeu aeu	𝔄𝔢𝔲 𝔞̈𝔲		as *oy* in boy		Bäume, trees; Bräute, brides.
Ei ei	𝔈𝔦 𝔢𝔦		as *ī* in fine		ein, one; mein, mine; kein, none; sein, his.
Eu eu	𝔈𝔲 𝔢𝔲		as *oy* in boy		Freude, joy; Leute, people; Feuer, fire.
Ie ie	ℑ𝔢 𝔦𝔢		as *ee* in meet		niemand, nobody; Riese, giant; Biene, bee.

COMPOUND LETTERS.

𝔠𝔥 (ch), 𝔠𝔨 (ck), 𝔣𝔣 (ff), ſ𝔠𝔥 (sch), ſſ (ss), ß (sz), ſ𝔱 (st), 𝔱𝔷 (tz).

THE VOWELS ARE.

𝔞 (a), 𝔢 (e), 𝔦 (i), 𝔶 (y), 𝔬 (o), 𝔲 (u).

It will be found advantageous to read these letters in a rearranged form, such as the following, in which the characters that are most like each other are brought together, at once for comparison and contrast:—

𝔠 𝔢 (c e); 𝔟 𝔡 𝔥 (b d h); 𝔣 ſ (f s); 𝔫 𝔲 (n u); 𝔪 𝔴 (m w); 𝔯 𝔵 (r x); 𝔥 𝔶 (h y); 𝔤 𝔮 (g q); 𝔨 𝔱 (k t); 𝔳 𝔶 (v y).

𝔄 𝔘 (A U); 𝔅 𝔙 (B V); 𝔑 ℜ (N R); ℭ 𝔈 (C E); 𝔚 𝔐 (W M); 𝔊 𝔖 (G S); ℑ 𝔗 (I T); 𝔇 𝔒 𝔔 (D O Q).

Read the letters also in the following order:—𝔞, 𝔪, 𝔠, 𝔟, 𝔩, 𝔲, 𝔷, 𝔯, 𝔰, 𝔱, 𝔞̈, 𝔞𝔲, 𝔥, 𝔭, 𝔮, 𝔳, 𝔢, 𝔦, 𝔲̈, 𝔦, 𝔨, 𝔟, 𝔡, 𝔣, 𝔤, 𝔬, 𝔴, 𝔵, 𝔞̈𝔲, 𝔞, 𝔦, 𝔠𝔨, 𝔢, 𝔲, 𝔰.

As further practice in pronunciation we subjoin here selections from the examples given in the above table, choosing only those words which may present some difficulty to the beginner. The words should be read *aloud* carefully and repeatedly. After each word the proper pronunciation is given, as explained in the alphabetical table, and the syllables on which the accents should fall are indicated by accent marks (′).

Mehl (mayl); Ehre (ay′rĕ); Esel (ay′sel); Ende (en′dĕ); Feld (felt); Titel (tee′tel); frei (frī); faul (fowl); frisch (frĭsh); Fürst (foorst); gut (goot); gütig (goo′tich); Huld (hoolt); Kuh (koo); vier (feer); Jahr (yar); jemand (yay′mant); Käse (kay′sĕ); Kaiser (kī′ser); Leben (lay′ben); Mutter (moot′ter); Meer (mayr); Natur (natoor′); Neid (nīt); niemand (nee′mant); Ochse (ox′ĕ); Ruhm (room); Flur (floor); Säbel (say′bel); Taube (tow′bĕ); Uhu (oo′hoo); Uhr (oor); Hut (hoot); Wald (valt); Zahn (tsan); zehn (tsayn); Schule (shoo′lĕ); Fäden (fay′den); Bäden (bay′den); Mädchen (mayd′chyen); Hände (hen′dĕ); Fälle (fel′lĕ); Sänger (seng′er); öde (oo′dĕ); Höhle (hoo′lĕ); Oefen (oo′fen); müde (moo′de); hüten (hoo′ten); pünktlich (poonkt′lich); Waise (wī′sĕ); Hain (hīn); Haus (hows); Baum (bowm); Raum (rowm); Bäume (boy′mĕ); Bräute (broy′tĕ); ein (īn); mein (mīn); Freude (froy′dĕ); Leute (loy′tĕ); Feuer (foy′er); Riese (ree′sĕ); Biene (bee′nĕ).

ENGLISH GRAMMAR AND COMPOSITION.

CHAPTER I.

GRAMMAR DEFINED—DIVISIONS STATED—PRONUNCIATION, SPELLING, AND CLASSIFICATION.

SPEECH, as the expression of intelligence, is peculiar to man. Words are the representatives of thought. Articulate sounds have been chosen as the medium of human intercourse, and constitute, as language, an essentially characteristic distinction and ornament of human beings. The correct and elegant use of speech requires a knowledge of the nature and structure of words as the instruments of the utterance of thought. Grammar is the science of spoken thought. It was in olden times the first of the seven liberal sciences which constituted the course of a thorough education, and were, under the twofold division of *Trivium* and *Quadrivium*, insisted upon as the indispensable branches of real knowledge. Grammar, logic, rhetoric; and arithmetic, geometry, astronomy, and music formed respectively the instrumental and the instructional divisions of scientific knowledge. Though, in our modern era, science has immensely widened her researches, grammar still continues to be a rudimentary requirement in an educational course, and holds a place in every curriculum of study.

Grammar implies a knowledge of language and a doctrine regarding it; hence it is a science. It is also a training or disciplinary study, intended to culture skill and to guide the powers of the mind in the use of words as their instruments. In this point of view it is an art. When grammar is taught as a series of truths, derived, by the study and research of others, from the actual usage of speech, it forms a body of instructions, founded on theory and established by induction, to regulate the practical employment of language. Grammar examines speech in its elements, combinations, and growth, gathers together the facts of the phenomena of language, traces the principles which operate through all the changes and variations which take place in its development, and sets forth the laws which regulate the use of speech when employed in the best manner by the best authorities. In each of these various duties its nature might be differently defined; but in all it would ultimately be found that grammar may most usefully be regarded as a practical science—as systematic knowledge intended to guide and improve the "use and wont" of speech.

On few topics of instruction does a larger library exist than on grammar, and the varieties of definitions of it which have been advanced, though not innumerable, are exceedingly numerous. The word *grammar*—derived from Gr. *gramma*, that which is written, a letter—implies that the language of which it treats is not any fugitive colloquial dialect that may be spoken, but one that is fixed and made visible in signs of some kind representative of the sounds employed, and so capable of deliberate critical investigation, record, exemplification, and reference. Speech precedes writing, it is true; but mere cursory speech is too volatile and indefinite for study. It requires to be fixed that it may be examined, examined that its principles may be investigated, and when investigated recorded and compared with the actual facts of the usages brought under inspection. On this ground grammar has been defined as the art of (1) understanding, (2) explaining, (3) writing, and (4) speaking a language correctly. Ben Jonson, the dramatist, who was one of the earliest of our grammatical instructors, says, "Grammar is the art of true and well-speaking a language : the writing is but an accident." Dr. Lowth more cautiously gives his definition in these terms—"Grammar is the art of rightly expressing our thoughts in words." It is doubtful if any adequate and accurate definition can be laid down in precise and peremptory terms. The utmost, perhaps, that can be really attained is some sound form of words which is likely to impart a general idea of the special matter on which grammar, as distinguished from other arts, conveys information. By no mere definition is it possible to communicate to a learner an informing knowledge of the subject. The skill of an artist in words requires time, care, and assiduity for its attainment; when it has been attained the artist can review and comprehend the learner's course, critically examine the definition, discover its full meaning, and test its accuracy.

It will answer every practical purpose to define grammar as the science of language, and to regard English grammar as a systematic knowledge of that language, founded on verified observation, arranged in such a way as to be regulative of practice and capable of being employed in criticism, and for guidance.

The English language is represented by twenty-six letters. A correct knowledge of letters and their combinations falls under two divisions (1) *Orthoëpy*, correctness of pronunciation and accentuation in speech and in reading ; (2) *Orthography*, correctness of representation in writing and spelling (which, of course, includes syllabification, &c.)

Letters are formed into words. A correct knowledge of words includes (1) Lexicography, an exact list of all the words which actually exist or are in use ; (2) Etymology, the derivation, formation, and development of words ; (3) Classification, the arrangement of words into distinct classes of different kinds ; (4) Flexion, the changes made in words to fit them for indicating (*a*) their relations to each other—inflexion ; and (*b*) the modifications which thought undergoes in different relations—conjugation ; (5) Syntax, the collocation of words in sentences, studied (*a*) in analysis or the decomposition, and (*b*) in synthesis, the composition of sentences ; (6) Prosody, the requirements of verse composition in rhythm and expression.

Of all the myriad minute peculiarities of difference of sound and stress, of spelling and syllabling, of inflexion and conjugation, of arrangement and melody, of enunciation of letters and pronunciation of words, of emphasis grammatical and elocutionary, &c., it has been found impossible to treat in a moderate compass. Hence, in practice, a considerable amount of what theoretically falls within its province has been usually left out in books on grammar. Orthoëphy is generally understood to be taught in the earlier stages of reading, and when further pursued is taken up as a department of Elocution. Orthography has furnished adepts with spelling-books, and remits its special functions to Phonetics and Phonography, or relies on dictation. Lexicography has betaken itself to dictionaries of varying dimensions. Etymology in its more erudite developments forms a portion of Philology, and much of what used to be treated of under the heading Prosody has had distinct treatment assigned to it in books on rhythm and versification. In this way theoretical grammar has been circumscribed in practice, and we seldom expect to find anything else in an ordinary course of grammatical instruction than such information as may confer a knowledge of the more striking and necessary of the facts and laws of language—those, in fact, which are indispensable to the proper use of speech as a practical acquisition and a definite study. A good many things are taken for granted as known. Considerable portions are set aside as, however curious and fitting for grammatical study or as a philosophical research, scarcely needed in the every-day conversation and composition of common life. The original design of grammar was to gather into one compact and well-arranged whole all the knowledge that could possibly be attained regarding speech as a literary product. The object sought in grammar in modern days is to bring together, in a concise and handy form, such a selection of statements and principles concerning language, as an actual agent in the intercourse of life, as may enable those who use it to avoid error, attain accuracy, and acquire a fair useful mastery of expression. It will suffice, therefore, to define the aim of our present endeavours to be to supply a brief trustworthy series of instructions in the right use of words in the expression of thought. The expression of a complete thought in words is called a *sentence*, as, Diamonds are clear. Each sentence consists of one or more *words*, as, Go ; Defeat is impossible. Each word contains one or more letters, as, A, oh, men, ornamental.

ORTHOEPHY AND ORTHOGRAPHY.

A few observations on the departments of Orthoëphy and Orthography may here be given as an aid to the understanding of some of the phenomena of language to which we shall be introduced.

The word "sound" is used in a double sense. It designates (1) a physical product, and indicates (2) a mental impression. Human speech is intelligible sound. As an outward phenomenon and product it is the result of the mechanical operation

of certain of our corporeal organs. As an intelligible means of transferring thought it owes, of course, its interpretability to the operations of the mind. Language is a union of sound and sense, now at least in a great measure conventional, by which sound, associating itself to significance, becomes the medium for circulating thought, emotion, and information. Sound affords the sign; mind affixes the signification. Art pictures sounds by letters, and hence that which was only perceptible by the ear is made tangible to the eye. Letters are the visible signs of audible sounds. That minimum collection of sounds which is adopted by a nation as intelligible signs in the transference of ideas constitutes its *alphabet*.

An alphabet is a conventionally accepted series of representative signs of the sounds made use of by any special community in circulating thought from one to another by speech. That it may be thoroughly representative, it ought to be the last result of a profound and accurate analysis of sound. This, however, has seldom been the case, and therefore almost all alphabets are redundant or defective, often both. Before a scientific study of prevalent sounds has been properly made, practical necessity arises for the representation, transmission, or registration of thought, and *phonetic* signs of the readiest sort available have been practically adopted and made *graphic*.

There are twenty-six letters made use of in English words, *a b c d e f g h i j k l m n o p q r s t u v w x y z*. *Articulation* is the accurate and distinct utterance of the elementary sounds of those letters which are used in combination to represent words. There are a good many singularities and peculiarities in the enunciation of several of these letters. Of the more important of these the following notice may be found sufficient—*l, m, p, b, d,* have only one sound each; *c* sounds *k* before *a, o, u,* and *s* before *e, i, y; j* has the sound of *g* soft; *x* is a compound letter sounding *gs* or *ks*, as exalt, box; *q* is only found followed by *u*, and then represents *k*. *C, j, x,* and *q* are therefore unnecessary as the letter-signs of sounds. *F* may have as its substitute *ph*, as philology, and *ugh*, as cough. *V* may not only have *ph* as its representative, *e.g.* phial = vial, but also *f*, as in of. The sound of *k* is produced by *c* in can, *ch* in character, and *q* in queen. *T* is represented by *ed* final, as in traced; *z* by *s* in was and treasure, *si* in confusion; and *sh* in terminations like *shion*, &c.

Breath is the material element in the formation of speech. The motion of the vocal organs moulds it into sound. As the compressed air which passes from the lungs issues from the larynx, between the edges of the glottis, it is brought under the power of the mouth, palate, tongue, teeth, lips, &c., and moulded into vocal sound. Mere vocal sound results in *vowels*, and vocal sound influenced by articulation of the organs of voice becomes transformed into *consonants*. The articulations of the voice-organs may be (1) complete in contact (*a*) of the lips, producing *p* and *b; (b)* of the tongue-tip and the teeth, resulting in *t* and *d; (c)* of the hinder part of the tongue and the palate, giving *k* and *g* (hard). If, while holding the voice-organs in the three positions described, the voice be allowed to issue through the nostrils, the following letters will be produced :—(*a*) *m*, (*b*) *n*, and (*c*) *ng* (nasal). (2) Partial in contact (*a*) of the lips, *f* and *v; (b) th* as in then, and *th* as in thou; and (*c*) *l* [and Welsh *ll*]. (3) Approximating towards contact, (*a*) *w* and *wh; (b) s* and *z; (c) r* vocalized and trilled, *h* aspirated, and *y* consonantal. In all these articulations we require to observe that there is, first, a position of the voice-organs through which the breath is passed, and next, a change of position of the voice-organs while the breath is passing. Distinctness of utterance depends on the firmness of the muscular position, and melody of speech depends on the pliability of the organs by which the movements are made.

The vowel *a* has four varieties of sound, as in ape, far, all, at, and each of these sounds is represented by a large number of substitutes—(1) *ā* by *ai* in sail, *au* in gauge, *ay* in clay, *ea* in great, *ei* in deign, *ey* in they; (2) *a* by *e* in clerk, *ea* in heart, *au* in laugh, *ua* in guardian; (3) *a* by *au* in taught, *aw* in law, *eo* in George, *oa* in abroad, *ou* in nought; (4) *a* by *ai* in plaid, *ea* in pageant, *ua* in guarantee.

Two sounds are given to the vowel *e*—(1) as in *eve*, (2) as in *end*, represented by (1) *i* in fatigue, *ay* in quay, *ee* in see, *ea* in eat, *ei* in seize, *eo* in people, *ey* in key, *ie* in field; (2) by *a* in any, *ai* in said, *ea* in wealth, *ei* in heifer, *ie* in friend, *u* in burial, *ue* in guess.

Two sounds are also assigned to *i*—(1) long, as in *ire*; (2) short, as in *it;* but these sounds are also taken by many other letters or combinations—(1) long, *ai* in aisle, *ei* in sleight, *ey* in eye, *ie* in die, *oi* in choir, *ui* in guide, *uy* in buy, *y* in try; (2) short, *ee* as in been, *ie* as in sieve, *o* as in women, *u* as in busy, *ui* as in build, *y* as in cymbal.

To *o* three sounds are given—(1) as in *old*, (2) as in *do*, (3) as in *ox*. But this also is represented in several ways—(1) for the long-*o* sounds we use *au* as in hautboy, *eau* as in beau, *eo* as in yeoman, *ew* as in shew, *oa* as in boat, *oe* as in hoe, *ou* as in soul, *ow* as in snow; (2) long and slender, *oe* as shoes, *eu* as rheumatism, *oo* as woo, *ue* as rue, *ou* as soup; (3) short, by *a* as in was, wan, *ou* as bought, *ow* as knowledge.

The vowel *u* has also (1) a long, (2) a short, and (3) a short slender sound, as in use, sup, full. The long-*u* sound (1) is also given to *eau* as in beauty, *eu* in feud, *ew* in dew, *ieu* in adieu, *iew* in view, *ou* in your, *ue* in hue, *ui* in suit; the short (2), to *e* in her, *i* in sir, *oe* in does, *o* in love, *ou* in young; the short and slender (3), to *o* in wolf, and *ou* in would.

The diphthongs *oi* and *ou* have their name-sounds in *oil* and *out*, and are also represented by *oy* in boy and *ow* in now, as well as *ou* in thou, couch, plough. There are no really triphthongal sounds in the English language. In buoy *u* is silent. The letter *i*, when followed by another vowel, is often pronounced like *y*, as in Asia, question.

Our orthographical system, as must have been noticed in the instances given, has many imperfections and anomalies—the same vowel-sound is represented by so many different combinations in words derived from various sources. Compare fated and fœtid, nay and neigh, ate and eight, shoe and blue. Some consonants vary their sounds, as gin, begin; care, cere; and the same sound is sometimes represented by different consonants—adds, adze; such, crutch; crack, stomach, &c. The following letters are sometimes not pronounced :—*b, c, ch, g, gh, h, k, l, n, p, ph, s, t, w,* as in de*b*t, lam*b*; *c*zar, s*c*ent, s*c*issors; s*ch*ism; *g*nat, *g*narl; hi*gh*, wei*gh*; c*h*asm, *h*onour, myrr*h*; *k*nead, *k*now; sa*l*ve, cou*l*d, wou*l*d; hym*n*, lim*n*; cor*p*s, concei*p*t, recei*p*t; *ph*thisis, apo*ph*thegm; i*s*land, vi*s*count; cas*t*le, rus*t*le, trai*t*; *w*rite, *w*rung, s*w*ord.

The English language is compounded of so many others, and its orthography has been exposed to so many influences, incidental and historical, that it is nearly impossible to fix and settle the spelling of its words according to any determinate phonic principles. It abounds in anomalies, and even among writers of distinction uniformity does not quite prevail: *e.g.* inquire and enquire, connexion and connection, surprise and surprize, negociate and negotiate, allege and alledge, &c., are to be found in highly reputable authors. It was formerly thought that spelling could be taught by rules, and spelling-books have been compiled with long lists of the irregularities of English orthography. It seems to us that careful reading, watchfulness while writing, and reliance on a good dictionary when memory or observation has been at fault, are the most efficient means for securing that education of the eye which detects at a glance an error in spelling, and feels, almost unconsciously, a sense of pain at any unusually spelled word. Trained carefulness and observant imitation are much more trustworthy than elaborate rules to which there are many exceptions.

The doubling of consonants sometimes occasions serious difficulty. The observance of the following rules will obviate that :—(1) A word ending in a single consonant preceded by a single vowel, if accented on the last syllable, doubles the final consonant before taking any affix that commences with a vowel, *e.g.* de-fer, de-fer-red; ad-mit, ad-mit-ted; com-pel, com-pel-led. (2) When the accent is on any other syllable than the last, the final consonant is not doubled, as dif-fer, dif-fer-ed, dif-fer-ent; prof-it, prof-it-ing; gos-pel, gos-pel-ed. (3) When monosyllables ending in a single consonant preceded by a single vowel take affixes beginning with a vowel,

the final consonant is doubled, as beg, beg-ged, beg-gar; bar, bar-red; glad, glad-der; shut, shut-ting. To the first and last of these rules there are no exceptions. To the second there are about sixty, almost all of which end in *l*—

Apparel-led,	Equal-led,	Model-led,	Snivel-led,
Barrel-led,	Gambol-led,	Out-general-led,	Stencil-led,
Bevel-led,	Gravel-led,	Panel-led,	Tinsel-led,
Cancel-led,	Grovel-led,	Parallel-led,	Trammel-led,
Carol-led,	Hovel-led,	Parcel-led,	Travel-led,
Cavil-led,	Imperil-led,	Pencil-led,	Tunnel-led,
Channel-led,	Jewel-led,	Peril-led,	Gallop-ped,
Chisel-led,	Kennel-led,	Pommel-led,	Bias-sed,
Counsel-led,	Kernel-led,	Quarrel-led,	Hiccup-ped,
Cudgel-led,	Label-led,	Ravel-led,	Kidnap-ped,
Dishevel-led,	Level-led,	Rival-led,	Nonplus-sed,
Drivel-led,	Libel-led,	Sentinel-led,	Worship-ped,
Duel-led,	Marshal-led,	Shovel-led,	Zigzag-ged.
Embowel-led,	Marvel-led,	Shrivel-led,	
Enamel-led.	Medal-led.	Signal-led.	

Vowels make speech clear, sonorous, euphonic; consonants make it distinct, strong, and expressive. These are the skeleton, those the flexible muscular fibres. Those impart beauty, fulness, and sweetness to speech; these give it resonance, power, and fixity. Each requires the other as its complement. The consonants embank and control the flow and movement of the vowels. By their co-operation syllables are formed. These are, properly speaking, the result of the combination of vowels and consonants into one organic articulate sound. In forming them the throat and the voice-mechanism are both active. A syllable is a vowel-sound either (1) alone, as *a* in a-way, or *o* in o-ver; (2) associated with such consonants as coalesce in making one simple sound with it, as *com* in command, *splen* in splendid, &c.

Words of one, two, three, or many syllables are designated respectively *monosyllables*, *dissyllables*, *trisyllables*, or *polysyllables*, as moon, move-ment, mo-tion-less, im-mo-bil-i-ty. The proper method of dividing words into syllables can scarcely be regarded as settled. One system professes to lay down the principle that the division into syllables should coincide, as far as possible, with the etymology of words, as guard-ian, an-oint; another, that the law for division should be, separate in syllabification so as to coincide with and indicate the pronunciation; while a third recommends that (1) if two consonants come together between vowels they should be divided, and (2) that each separate syllable should, as far as possible, begin with a consonant. Each of these, in some measure, yields fair general results; but they all have many exceptions. Perhaps the only definite rules that can be given are—(1) *Compound* words are separated into their original elements; (2) in *composed* words, prefix, root, and affix are generally separable; (3) where the composition and the pronunciation do not coincide, it is better to follow the latter, as pre-fer, pref-er-en-tial; (4) a long vowel often stands in an open syllable, and a short vowel in a shut one, as si-lent, sil-ver; ta-ble, tab-let; bo-tan-ic, bot-a-nist. To a spelling-book and a dictionary the student must be referred for all other matters relating to orthoëpy and orthography.

THE CLASSIFICATION OF WORDS.

Syllables form words, and words are in reality the first elements in grammar as the science of speech, for speech is sound employed as the messenger of intelligence. Hence words are the least *parts of speech* capable of grammatical *classification*. For as a sentence communicates thought, and is composed of words which transfer that thought to the mind, each word must bear some part and have some separate force in relation to the meaning of the whole sentence. It is a factor or agent in conveying to the intelligence of another the thought which it has been commissioned to bring from the speaker. Can the power of words be thus discriminated and set before the mind in parts? If so, we have a basis for classification. We can distinguish words into classes by the office they perform. All words may be regarded as expressive of ideas and their relations. Ideas are the mind's representations of outward objects, supplied by the organs of sense, and any mental conception which can become the immediate subject of thought. Ideas of perception and objects of thought receive names representative of them to the mind. These names (from the Latin word *nomen*, a name) of things recognized and known by the mind are called *nouns*. Everything becomes known to man either by its qualities or by its actions. In fact, it is—as we shall find if we attempt to define any special object or notion—by the addition of words which mark the distinguishing qualities of the thing that we contrive to describe and characterize it to ourselves or others, and so either know it or make it known. Those words which we thus add to a name to specialize it are from that fact called *adjectives* (Lat. *adjectivus*, annexed). As man is an active living being himself, he looks on all things with the expectation of finding them living and active. The important thing for him to know and to speak of is—What do things do?

From the opinion of some grammarians that all words were originally expressive—or at least indicative—of actions, such words are called *verbs* (Lat. *verbum*, a word). They are certainly words without which—either expressed or understood—sentences could not be made, and therefore may be permitted to take the position their name claims for them, as the word indispensably required to make a complete sentence. As masters often have persons who represent them, work for them, and stand in their stead in special circumstances, so have nouns words which may be substituted for them. These are called *pronouns* (Lat. *pronomen*, a word used instead of a *nomen*). All these classes of words refer to existence, qualities, and acts which are liable to changes and alterations These changes are indicated by changes made in the words used to denote them, and hence the foregoing parts of speech are said to be *inflected* (Lat. *inflecto*, I change).

The relations of things and of thoughts are very numerous, though they may all be brought into a few classes, for which different kinds of words have been (and are) employed. Qualities and actions are subject to alterations in the time, place, manner, degree, and conditions in which they are experienced or manifested. Owing to the frequency with which words expressive of such incidental alterations are used in connection with verbs, they have been called *adverbs* (Lat. *adverbium*). The relations of the existences around us are very numerous, both among themselves and towards us. The words employed to indicate these are generally placed before the names of the object whose relations they denote, and from this circumstance they are called *prepositions* (Lat. *præpositus*, set before). Not only have the existences among which we live and move many relations, but our thoughts have also many relations one towards another. The several connections of thought with thought are indicated by a set of words which it would be very difficult to analyze, but the uses of which are sufficiently known in practice to give them good right to be called *conjunctions* (Lat. *conjungo*, I bind together). Signs of emotion are apt to show themselves under many circumstances, and to make their appearance in unexpected times and places. A few of the more common emotions have acquired a small but expressive literary vocabulary, and from the unallocated place they take in the sentences of which they form a part they receive the name of *interjections* (Lat. *interjectus*, thrown between or among). These words for the most part are uninflected, and though few in number re-appear very frequently as elements of speech. The foregoing classifications of parts of speech may be brought before the eye and exemplified in a tabular form, thus:—

PARTS OF SPEECH.

INFLECTED.

Noun.	Adjective.	Pronoun.	Verb.
Man	good	he	lives

UNINFLECTED.

Adverb.	Preposition.	Conjunction.	Interjection.
Freely	in	and	oh!

With some endeavour to supply concisely definition and exemplification at one view, the following table is formed:—

Words are :—

I. Notional, signifying—

- Existences,
  - 1. Noun,
    - 1. Proper, John.
    - 2. Common.
      - 1. Real, sun.
      - 2. Ideal, fairy.
      - 3. Abstract, glory.
      - 4. Collective, army.
      - 5. Adjectival, goodness.
      - 6. Verbal, reading.
  - 2. Pronoun,
    - 1. Personal, I.
    - 2. Relative, who.
    - 3. Adjective.
      - 1. Possessive, mine.
      - 2. Demonstrative, this.
      - 3. Distributive, each.
      - 4. Indefinite, some.
- Qualities—Adjective, .
  - 1. Proper, Alexandrian.
  - 2. Common.
    - 1. Real, sweet.
    - 2. Ideal, remarkable.
    - 3. Verbal, repeated.
    - 4. Numeral, four.
- Actions—Verbs. . . .
  - 1. Transitive.
    - 1. Active, love.
    - 2. Passive, am loved.
  - 2. Intransitive, walk.

II. Relational, indicating—

- The Relations of things to each other—Prepositions, ...
  - To, by, from, over.
- Relations and Modifications of Qualities—Adverbs.
  - 1. Time, soon.
  - 2. Place, above.
  - 3. Manner, rapidly.
  - 4. Degree, greatly.
  - 5. Condition, allowably.
- Relations between thoughts —Conjunctions, . .
  - 1. Co-ordination.
    - 1. Copulative, and.
    - 2. Adversative, but.
    - 3. Causative, since.
  - 2. Subordination.
    - 1. Divisative.
    - 2. Alternative, either, or.
    - 3. Contingent, if.
- Emotions—Interjections, oh! ah! &c.

GEOLOGY—CHAPTER I.

INTRODUCTION—DEFINITION—GEOLOGICAL PHENOMENA—AND THE ANTIQUITY OF THE EARTH.

In walking over the surface of a country we witness its undulations, its mountains, and its rivers, and are apt to conclude that its scenery of hill and valley, river and lake, has existed in nearly the same condition since time began its ceaseless course. But when we examine the structure of mountains, the causes of undulation, the alterations which have taken place in water-courses, nay, even in the general configuration of the globe itself, as well as in particular regions of it, we naturally feel inclined to reflect that "the hills themselves are the daughters of time, the waves of the present ocean played in past ages on other shores, and the rivers which now supply it are derived from surfaces which in ancient days were below the level of the deep—all that is now land is but the *débris*, or worn and wasted fragments, of continents and islands now unknown, the wreck of a former world, the spoils and the sport of time." Effects have been produced which, if attributed to the ordinary agencies of nature, require the imagination to stretch its glance though a lapse of ages at least as inconceivable in duration as the distances of the stellar spheres are in the field of space.

"At the first step we take in geological inquiry," says Dr. Mantell, "we are struck with the immense periods of time which the phenomena presented to our view must have required for their production, and the incessant changes which appear to have been going on in the natural world; but we must remember that time and change are great only in reference to the faculties of the being who notes them. The insect of an hour, contrasting its own ephemeral existence with the flowers on which it rests, would attribute an unchanging durability to the most evanescent of vegetable forms, while the flowers, the trees, and the forest would ascribe an endless duration to the soil on which they grow; and thus, uninstructed man, comparing his own brief earthly existence with the solid framework of the world he inhabits, deems the hills and mountains around him coeval with the globe itself. But with the enlargement and cultivation of his mental powers he takes a more just, comprehensive, and enlightened view of the wonderful scheme of creation; and while in his ignorance he imagined that the duration of the globe was to be measured by his own brief span, and arrogantly deemed himself alone the object of the Almighty's care, and that all things were created for his pleasure and necessities, he now feels his own dependence, entertains more correct ideas of the mercy, wisdom, and goodness of his Creator; and while exercising his high privilege of being alone capable of contemplating and understanding the wonders of the natural world, he learns the most important of all lessons—to doubt the evidence of his senses until confirmed by patient and cautious investigation."

Were we to assert, therefore, that the present continents of Europe, Asia, Africa, and America were once wholly immersed under the waters of the ocean, and that after rising at different spots in low new-born islands, they gradually acquired their present configuration—nay, that the whole materials of which both the present continents and their islands are composed, have resulted from the denudation of continents and islands which have been worn away, or finally sunk under the all-encroaching influence of the waves—we would not be merely making assertions with a view to the excitement of astonishment and to rouse the reader's wonder; we would be stating, in plain unvarnished terms, the conclusion to which all who study the structure of the earth, alike by observation, induction, and reasoning, are necessarily led. It is the "delightful task" of geology to examine and study these monuments of ancient ages, "the strong rocks," and to extract from them something like a continuous history of the earth, from the time when it became the receptacle of life to the present hour.

Geology (Gr. *gê*, the earth, and *logos*) etymologically signifies the science of the earth. This, like many other merely verbal definitions, is very wide. It would include not only all actually acquired, but even all possible, knowledge of the phenomena upon, within, and influentially surrounding the globe. Of such a collection of methodized facts and systematically arranged principles as this would involve, Sir John Herschel was probably thinking when he spoke these words, "Geology, in the magnitude and sublimity of the objects of which it treats, undoubtedly ranks, in the scale of the sciences, next to astronomy." The relations of geology to other branches of human knowledge have been thus pithily described —"To astronomy belongs the investigation of the earth as a part of the planetary system, and the results thus reached help to correct and limit geological inferences. Chemistry employs itself upon the inquiring into the laws and modes of mutual action among the particles of matter, and gives its results to aid in the general history of terrestrial phenomena. It is the province of zoology and botany to arrange and interpret the facts connected with life and organization in plants and animals, and to these branches of knowledge, geology owes immeasurable obligation. Thus, the study of the ancient history of the earth draws help from every kind of inquiry which man can make into the actual condition of nature, but robs none of its interest or glory; on the contrary, by the novelty of its discovered facts, fresh problems are presented to the cultivators of natural science, and a perpetual excitement is kept up, which has proved of infinite service to them all."

Modern geology does not aim at surveying so wide a field, or mastering so vast a host of details, as the literal acceptation of the term would imply. It confines itself to the examination of the existing appearances of the materials of which the earth is formed, and seeks to determine by accurate observation the real phenomena of the globe as a member of the planetary system, and as the theatre of those changes—mechanical, chemical, vital—which men have observed and wish to understand. This furnishes (1) *descriptive geology*. But any accurate actual survey of the phenomena of the earth brings before us evidences that the earth has undergone many changes before reaching its present stage. Concerning these

modifications we are naturally curious. We desire to know their order, their conditions, and their precise effects. Such a knowledge might be called (2) *historical geology*. The mind, however, is prone to speculation, and inclined to infer from the facts presented in these investigations the causes which have regulated and probably do regulate the successions of the conditions which the phenomena of nature reveal. This, could we realize it, would supply a theory of the agencies, changes, materials, and structure of the earth, *i.e.* (3) *theoretical* or *philosophical geology*, or a scientific exposition of the causes of the changes in the phenomena of the earth's surface, and of the nature and extent of their action.

Geology takes for its text "the crust of the earth"—that exterior portion of the globe, composed of rocks and materials derived from rocks, which can be seen and handled, and so subjected to scrutiny and inspection. The surface of the earth, not as the theatre of geographical phenomena, but in itself, is the field of the geologist's investigations. The most cursory observer by footpath, in steamboat, or by railway cannot fail to note the upheaved hill, the level plain, the rugged rock, the steep ravine, the tall sea-cliff, the river channel, the fertile or the sterile field, the quarry, the clay-bed, the peat-moss, and the coal deposits. The shores of inland lakes, the cuttings on railway lines, the waysides of the daily walks of men, supply the phenomena which geology considers, and from which it seeks to extract some knowledge of the history and constitution of the surface of the globe. The process of waste and reconstruction, of denudation and submersion, of upheaval and of fall, of aqueous, atmospheric, and igneous forces, of modification by external operation and by internal force, of composition and decomposition, and many other topics of inquiry, are suggested to the thoughtful in their daily walks among ordinary scenes. But we read of other phenomena beyond, or at least coming rarely within, our ordinary experience—of volcanoes, earthquakes, avalanches, glaciers, icebergs, and ocean currents—which create changes in the physical aspects of the earth. These we wish to understand. We trace the devastations they work or the alterations they occasion with curiosity and wonder. Amid all our associations connected with nature and our knowledge of the incessant mutual actions of the different forces operating upon each other, these show us that there are mighty agencies also working to effect changes on the terraqueous surface of this planet which require study and will repay investigation. Of the part these play in the scheme of nature geology takes knowledge, and it endeavours to explain the results of their operations on "the crust of the earth."

Those who really wish to understand fully and scientifically the structure of the earth must take "a hammer that breaketh the rock in pieces" in their hand, and in many a journey over the breadth and length of the land ascend the hill, dive into the ravine, descend the mine, explore the river, and investigate the shore. Unless that is done geology will never completely open up her treasures to the understanding. Read, speculate, reason, and wonder as you may, unless you are a *working* you can never be a *practical* geologist. But all are not capable of undertaking this laborious task. Few have time, and still fewer have the other resources required for such a study. Truth is not to be hid from the understandings of the people in these times when curiosity and culture are alike astir, and so urgent a demand is made that the deductions of geological investigation may be exhibited in forms available to intelligent readers and stay-at-home students.

It will be the aim of these chapters to present a brief outline of the views of modern geologists in a manner likely to combine interest and instruction, and calculated not only to gratify curiosity, but to satisfy the intelligence of our readers. That the earth is a round globe or ball which performs a revolution on its axis *daily*—*i.e.* every twenty-four hours—and moves, with inconceivable velocity, in the path of its orbit round the sun *once a year*, are facts now familiar to every one. It is also a well-known fact that the earth is perfectly round, but of a sphere-like form, having its polar axis about 26 miles less than its equatorial diameter. About three-fifths of its surface are covered by the ocean. The land rises from the surface of the sea in great continuous masses (called *continents*), which have no regularity of outline, either when they stand out from the water or penetrate the air. Its land-surface is singularly diversified, and sometimes rises nearly 30,000 feet above the level of the sea. Soundings taken in different parts of the globe have shown that the sea-bottom is as diversified as the upper surface, and that what we call islands are really the peaks of mountains rising up out of the ocean. These phenomena elicit research, and science brings us the results thereof in physical geography and geology.

The spherical figure of the earth is that form which bodies necessarily assume whose particles have free motion among themselves when they are subject, like the earth, to a rotatory motion. It has been thence inferred that the whole matter of the globe once existed in a fluid state—a supposition strongly confirmed by its other phenomena. What form the first consolidated masses on the earth's surface assumed, or whether any such now exist, we have scarcely sufficient data given us to determine; but the oldest stratified rocks, gneiss and mica slate, being evidently derived from the disintegration of granite, it is not improbable that the original mass of our earth-system, when first consolidated, assumed the different crystalline forms of that rock. Lyell has carried this metamorphic theory so far as to consider granite itself a result of rocks having a prior origin, and that the tendency of all rocks, however new, is to pass onward to the metamorphic state seen in granite and such rocks as are usually denominated Primary. Others are, however, disposed to consider gneiss and mica slate as depositions of matter derived from the granitic floor of the earth, and that granite represents the primordial condition of the *crust* of the globe. The confused crystallization which characterizes granite shows its former state of fluidity, for fluidity is indispensable to the process of crystallization; and hence, from the granular structure and crystallized nature of granite, as well as from the spherical figure of the earth, warrant is found for believing in our earth's original fluidity. The only adequate known cause of that fluidity is heat, and the radiation of that heat the cause of its ultimate solidification.

Perhaps a statement of some very familiar facts may bring more easily into our minds the considerations which have led men to interpret experience in geological science. Suppose we dig through the vegetable soil or mould which forms in many places the upper covering of the earth, we very frequently reach a mixture of sand, clay, gravel, or some other unconsolidated materials; and in some cases we may not, even at the greatest depths to which we can penetrate, come to anything else. In most instances, however, after getting through the surface mould and the mixed materials underlying it, we would reach hard stone, in solid layers—called by geologists strata or beds—parallel to one another, either of one kind or of different kinds, according to the depth we went. These would vary not only in different countries, but in different places in the same country, and that, too, not merely in the constituent parts or elements of which they are made up, but even in thickness, position, and alternation. By putting together the facts ascertained by observers in many different portions of the globe, it has been found that the crust or upper surface of the earth is composed of a series of these layers, each distinguishable from the other by marked peculiarities. These constitute the rock-leaves, whose inscriptions geology endeavours to decipher, read, and translate.

Nor is it so easy, as at first sight it would seem, to learn all the knowledge that has been "graven in the rock for ever," for besides that their simple elements are aggregated and massed together in so many proportions and forms as to produce a considerable variety of substances, a large proportion of what are termed the sedimentary rocks, that is, those which are disposed in layers, contain foreign bodies—such as shells, bones, portions of trees and plants, and fragments of other rocks—of which account must be taken. Some of these animal and vegetable substances are found quite fresh, others have been transformed into substances similar to the rocks which inclose them, and in some cases the original substance of them has entirely perished, and the hollow casts or moulds of them alone remain.

More singular facts than these even come out into prominence from the phenomena of the sedimentary rocks. The

remains of animals and plants, of such sorts as could only exist and grow to maturity in the heat of tropical regions, are now found embedded among the strata of rocks which form the surface of cold countries, and it is said, on the unexceptionable authority of the late Prof. John Phillips, that "The organic remains of plants and animals which abound in the earth are not those of the tribes which now live, but of many wholly extinct, and often quite different races, different in form and structure, and consequently in the functions of life, though certainly belonging to a general system of nature founded on analogous principal conditions. Further, it is not sufficient, nor correct, to say there is one living and one extinct creation. The plants and animals buried in the earth belong to many distinct and successive creations, which differ among one another no less than they almost all differ from the actual forms of life."

Geologists, reasoning from the facts observed in the stratified rocks, have thought they could find some clue in them for the determination, if not of their real, yet of their relative ages. They argue, for instance, from the laminated nature of many of the sandstones, and of the shale or slaty clays, and their being frequently impressed with the ripple marks of the ancient waves, that almost the whole of this immense mass of deposition was accumulated under the influence of comparatively tranquil water, and consequently that the time must have been immense during which these deposits were formed. And however much they may differ among themselves as to the length of the eras they reckon, they have with entire unanimity come to the conclusion, that the whole stratified rocks which constitute the crust of the earth are derived from matter deposited by water at the bottom of the sea, in estuaries, or lakes, which at the time were inhabited by animals differing in species, and many of them in genera, from any that now exist; and that consequently the present structure and configuration of the earth are of vast antiquity.

The reasoning by which, in this particular connection, the foregoing conclusion is supported may be epitomized thus:— The rocks of which the crust of the earth is chiefly composed occur in beds or layers. On examining these we find every evidence of their having resulted from matter carried by rivers as *detritus*—*i.e.* fragments or small particles detached by natural agencies from the surface of older rocks—into lakes, estuaries, or seas. This is demonstrable, for some of them are composed of fragments of other rocks worn and rounded by the action of water, so as not to be distinguishable from the gravel strewed upon the shore, or which we meet with in the path of a mountain stream, except in its having been consolidated into a stony mass—such rocks are called *conglomerates.* The red sandstone formations of Arran, and the coasts of Argyle and Ayrshire, consist of immense beds of such rocks, alternating with layers of red clay and red sandstone. This formation itself is many thousand feet thick. We never find, in it, any fragments of coal, or of any of the newer formations; on the contrary, the conglomerates consist solely of pieces of quartz, slate, red sandstone, and other rocks of more ancient date. In the strata of the same formation, which stretch from Argyle through Stirlingshire and Forfarshire to the eastern coast, remains of fishes in a very perfect state of preservation have been found. Both in the conglomerates, then, and in the fishes contained in the sandstone strata referred to, we have evidence of this formation having been produced, not instantaneously, but through a long succession of ages.

Stratified rocks, not only by their lying in parallel beds or laminated succession, and by the remains of organic creatures they contain, but by the pebbles and *débris* of pre-existing rocks of which in a great measure they consist, demonstrate that they must have been formed under water by deposition from the surface downwards, through the agency of a fluid which held their materials either in suspension or solution until they gradually sank and settled. It is perfectly plain, then, that each bed of pebbles, if the ancient agencies of nature were in any way analogous to the present, must have been the work of many years. That these agencies were not more violent, or at least that there were long intervals of repose, is attested by the beds of fine-grained sandstone and consolidated mud with which the conglomerates alternate.

The largest of our existing rivers, in rainy seasons, carry great quantities of gravel, sand, and mud into their estuaries or into the sea; but great as the amount of this *débris* is, the production of a quantity of matter in any way equivalent to that of the old red sandstones of Scotland or England could not have taken place except in the lapse of innumerable ages. The mud carried down and deposited by the Nile amounts to about 3 or 4 inches in a century. The old red sandstone is estimated at from 3000 to 4000 yards in thickness. If we allow from 3 to 4 inches as the depth of deposit in a century, this formation—calculating on the *data* of our present experience—could not have been deposited in less than 3,600,000 years. If we contemplate for a moment the agencies that must have been engaged in wearing down the surfaces of the ancient rocks, and in transporting them over the vast areas they now occupy, the time here stated will not seem in any way exaggerated, but far too little for the amount of the effects produced. We have mentioned the old red sandstone as one instance, from which something like an idea may be formed of the time requisite for the production of a certain class of rocks. The same, or similar, if not still more decisive, proofs of the lapse and change of time are afforded by other formations. The silurian rocks, which occur between the clay-slate and the coal formations, and from their being prevalent in Wales receive their name from the ancient inhabitants of that country, the *Silures*, underlie the old red sandstone of England, and these are also estimated at 3000 yards in thickness. The slate rocks of Scotland are several miles in thickness, and all exhibit marks of slow deposition and subsequent consolidation. The whole slate or schistose formations of the West Highlands of Scotland generally crop out in a north-west direction, and lie in an angle of from 45 to 70 or 80 degrees. They extend from about 5 miles below Dunoon, along the whole coasts of Loch Long and Loch Lomond, with nearly the same inclination. The slate rocks of England, underlying the silurian system, are also of immense thickness.

That the stratified portions of our earth have resulted from sedimentary depositions, such as those we witness in rivers, at the mouths of estuaries, and in lakes, may now be regarded as demonstrated, and cannot fail to be accepted as evident (1) from the fact of their stratification and the time required for their deposition in layers, and (2) from the vast abundance and the perfect state in which they are embedded in their strata; all of which, by the organic remains found in them, attest the ancient conditions of animal and vegetable life upon the surface of the earth, during each successive period of their deposition.

The vast antiquity of our globe may now therefore be considered to be as fully demonstrated as its rotundity; and the mighty lapse of ages which must have occurred in the completion of a geological epoch is as evident as the immensity of the distances of the heavenly spheres: indeed, far more so—because the one can be proved to any person in the slightest degree conversant, through his own experience, with the structure of the earth, by deductions the most rational and satisfactory, and by evidences the most complete; whereas in astronomy the person who cannot use the telescope and master the recondite problems of algebra and geometry, must in a great measure rest satisfied with the testimony of the astronomer and the collateral evidence of the mathematician.

One of the most able and eloquent expositors of this important and interesting science refers in these animated terms to the topic under consideration:—"The chief evidence which geology offers on the date of the earth is afforded by the number, variety, and contents of those materials which form the crust or covering of the globe. Many of these consist of accumulations of igneous matter, lavas and basalts, which, judging from the progress of an Etna or Vesuvius, must have required thousands and millions of years for their deposition; these are succeeded by fossiliferous rocks, the mineralized beds of primeval seas, when oceans rivalling the Pacific or Atlantic in extent, and consequently in duration, must have prevailed during incalculable epochs, and then must have passed away to give occasion to fresh and equally extensive phenomena. The seas then became dry land, forests of

tropical plants spread over the newly-formed earth, and, after their cycle of date and prevalence, were entombed beneath the waters to elaborate supplies of mineral fuel, and yield to mankind the invaluable blessing of coal. Fresh seas succeeded, teeming with fresh forms of life and being, adapted to the ever changing conditions of external nature; while dry land obtained at intervals, lakes were developed in turn, and deposited their sediments and organic remains; the volcano and the earthquake occasionally burst forth in paroxysms, and every variety of revolution and disturbance at once diversified the then existing aspect of nature, and furnished elements for successive changes of condition. And when we compare existing nature with nature in bygone eras, when we reflect that nothing is created in vain—nothing made for a day, but that everything has its sphere of usefulness and of duration—when we remember that the oceans of the present day, with some trifling modifications, have prevailed during the entire historic period, that the same Channel crossed by Cæsar still parts the Briton from the Gaul; the same Atlantic still divides the Old World from the New; while the seas and rivers navigated by Alexander are in existence now—we cannot refuse our assent to a proposition so self-evident as the fact that changes so numerous and extensive as we have mentioned, must have required an adequate space of time for their development, and that a world made up of changes so numerous and diversified must have occupied a corresponding space during its preparation. The antiquity of the earth is a fact demonstrated by evidence of so cumulative, so convincing a character, and constitutes so essentially the foundation of all judicious inquiry into the nature and condition of our planet, that it forms an early lesson in every work on geological science. If there be a contemplation which, more than any other, enhances our admiration of Divine bounty and benevolence, it is that which this science so admirably supplies, by representing the Creator as first fitting up and providing this beautiful and harmonious earth with every variety of boon and blessing, and storing it with metals, with limestones, with sandstones, and, above all, with coal; adapting it for every variety of soil and cultivation; making it a sphere in which every industrial and active faculty of man could be beneficially and usefully employed, and, finally, moulding it into external beauty and loveliness; diversifying it with land and sea, with lake and forest, and river and plain; clothing it with vegetation, and harmonizing all its attributes into one consent of grace and plenty and loveliness."

ALGEBRA.

PRELIMINARY REMARKS ON THE PRINCIPLES, HISTORY, AND METHODS OF ALGEBRA.

Algebra is a branch of mathematical science in which the reasoning employed in the solution of all problems relating to numbers is generalized and abridged by the use of general symbols of quantity and of the conventional signs of operation employed in arithmetic. By Newton it is called *universal arithmetic*, and, in some respects, the appellation is appropriate; but between algebra and arithmetic there is this distinction—in arithmetic the signs of number (figures) have a determinate connection conventionally agreed upon and universally recognized, and our object is to combine them together according to certain rules; in algebra, on the other hand, the symbols employed have no determinate connection, nor is it a numerical result which we seek to obtain, but the manner in which the several numbers enter into the calculation. Where algebra terminates arithmetic begins: the former investigates the conditions of the problem, and discovers the relations subsisting among its terms; the latter deduces, by a special application of the principles evolved to particular numbers, the numerical result. By working an arithmetical operation, we obtain a result the value of which is known when the value of the unit is known. But the algebraical result of an operation is independent of all numerical convention; it is simply a general expression, in symbolical language, of the arithmetical operations which must be performed to obtain the numerical answer; it is, in fact, the arithmetical rule by which all questions of the same class may be resolved.

This is the character, at least, of one great department of algebra, expressed in very general language. To render it more explicit, let us proceed to particular examples of the two species of calculation. If it be required to add the numbers 4, 3, 7, we readily find that their sum is 14. This result (14) is an isolated quantity; it does not indicate the nature of the operation of which it is the result; it might have been obtained by adding together 7 and 7, or 6 and 8, or any other pair (or series) of numbers whose sum is 14; and it might, moreover, have been found by any other arithmetical operation upon certain numbers besides addition. But if, instead of combining the three given numbers into one sum, we show simply the manner in which the calculation is to be effected, and write $4+3+7$, we preserve in this, the enunciation of the question, not only the successive steps of the operation to be performed, but also the respective quantities which enter into the calculation. By prefixing, in the same manner, to all the quantities which compose the terms of a problem the particular signs which express the arithmetical operations to be performed upon them, we are able to represent the result by means of the given numbers and the known symbols of operation. But it is particularly required to remember that exemplification is not demonstration. From particular premises no universal conclusion can justly be drawn. Every arithmetical problem is merely an exemplification of one or other of the particular rules which have been laid down for guidance in calculation, and however correct each may be found to be, in its results, each is, in reality, only a single instance of the rule's holding good. Very many such demonstrations by special instances would fail to give good ground for a universal proposition. In point of fact, disguise it as we may, universal results and general demonstrations are impossible in merely arithmetical calculations, and hence algebra, the science of analysis and of demonstration through analysis, has been invented to supply the means of knowing the general results of universal operations.

Augustus De Morgan gives as the derivative source of the name *algebra*, the Arabic phrase *Al jebr e al mokālabah*, of which "the nearest English translation is," he says, "restoration and reduction." F. Schöll, in his "History of Greek Literature," says that it "was called algebra in honour of the Arabian Geber, to whom its invention is ascribed" (vii. 43). Neither derivation adds much to our knowledge of the subject. Modern Europe received its earliest knowledge of this science not from the Greeks, who had first cultivated it, but through the Arabs, who are reported to have acquired it from the Hindus. The earliest European treatise in which problems similar to those of algebra are treated is the "Arithmetica" of Diophantus of Alexandria, who probably lived in the days of the Emperor Julian. From him the Diophantine problems take their name. His operations are so like those of the Hindus that we must conclude either that the Hindus borrowed from him or he from the Hindus. Delambre, in his "History of Ancient Astronomy," says, "The Hindus had algebra of the first and second degrees; they knew how to solve indeterminate problems, and they made these acquisitions themselves. They are also the authors of the system of arithmetic now universally received by us" (vol. i. 556).

By Mohammed Ben Musa, who lived in the reign of Caliph Al Mamun, in the early part of the ninth century, algebra was first introduced into Europe. Of his treatise, "On the Measurement of Plane and Spherical Figures," Dr. F. Rosen, under the auspices of the Oriental Translation Fund, produced an English version in 1831. Spain and Italy were the countries in Europe upon which the light from Ben Musa's lamp fell. Into the former it was introduced by eminent Arabian scholars, who taught in its colleges and deposited MSS. in their libraries; into the latter it seems to have gained access somewhat accidentally. Leonardo Bonacci, a wealthy merchant of Pisa, requiring to visit some of the Asiatic provinces on business, associated a good deal with the learned men of Bagdad, and being intellectually inclined, made himself acquainted with the most important elements of knowledge which they were willing to communicate. This knowledge he imparted to his countrymen, and through him this agent in accomplishing some of the most remarkable achievements of human intelligence was expounded and

popularized in Italy. Luca Paccioli di Borgo, a Minorite friar, in 1494, was the author of the first printed book on algebra; Scipio Ferreus and his pupil, A. M. Fior, between 1505-35, constructed and solved many ingenious problems. In 1535 Fior and Tartaglia had an algebraic contest at Bologna, at which the latter was victor. Zuanne da Coi, of Brescia, was acknowledged by Tartaglia as a master. Jerome Cardan issued his "Book of the Great Art" (algebra) in 1545. His favourite pupil, Lodovico Ferrari, and R. Bombelli carried forward the light of the Cossick art, as it was called in Italy. Except among these algebra did not make any very decided progress in that country, and it was nearly the middle of the sixteenth century before it received a place among the studies of the higher minds in Germany, France, and England respectively, by M. Stifelius, J. Pelatarius, and Robert Recorde. It was in Michael Stifelius' "Arithmetica Integra" that the signs $+$, $-$, $\surd$ were first used. Christian Rudolf had, in 1542, introduced algebra into German culture, Pelatarius' "Algebra" was published in 1554, and Robert Recorde's "Whetstone of Witte" was issued in 1557. In it he suggested the sign of equality, $=$. François Viète, an illustrious Vendéan (1540-1603), holds high rank among the French cultivators of this science. He introduced the use of letter-symbols, and is regarded as the precursor of Descartes. In England Harriot, and in Holland Girard, improved upon Viète, and Descartes applied algebra to the elucidation of geometry. We do not profess to write a history of algebra, but only to note the landmark-names in the course of its progress. Newton's "Arithmetica Universalis" (1707), and Fermat's mathematical discoveries made distinct advances in the science, and from their time the modern methods and aims of algebra may be regarded as having settled into form.

Algebra had now attained a workable language. Its notation may be regarded as the most perfect and concise system of written characters. It is quite transparent and fully explanatory. In the latter portion of the seventeenth century, and during the course of the eighteenth, it acquired greater perfection in details. Leibnitz, Euler, Raphson, Halley, Lagny, Taylor, and others improved its processes; Montmor, De Moivre, the Bernouillis, James Stirling, and Maclaurin made many ingenious applications of its principles; Stephen Bezout and Edward Waring displayed originality and power in their analysis of elimination; Pascal, Wallis, Hindenberg, Rothe, and Pfaff carried out to new issues combinatory analysis; Mayer and Mollweide applied algebra to geometry and questions in physics; Saunderson, Laplace, Lagrange, Simpson, Emerson, and others imparted clearness and method to the explanations of the theory. It has now become one of the most valuable of the agents of practical research. Among its modern expositors Abel, Barlow, Fourier, Peacock, De Morgan, Hind, Kelland, Whewell, &c., may be named. Admirable practical works in this science are due to Baily, Cauchy, Grunert, Heis, L'Huilier, Lagerwij, Orlebar, and Strootman. Auguste Comte, De Morgan, George Boole, Stanley Jevons, &c., have carried out its principles into logical and metaphysical researches; Sylvester and Kingdom Clifford have widened its theoretic range, and every year adds to the number of those who apply the algebraic calculus to vaster inquiries and wider problems than were even thought of a few years ago.

The library of algebra is immense. The sweep of its power is wonderful. It carries its calculus into almost every region of human knowledge helpfully. The training it imparts when pursued, not mechanically, but intelligently, is most valuable, and the extreme simplicity of its various stages renders it progressively attractive. Any student who has acquired an ordinarily exact acquaintance with the four primary rules of arithmetic, a moderate training in reduction, proportion, and fractions, need not hesitate to apply himself to algebra. He will comprehend all the specific directions given to him, and every step taken in algebraic study will aid his progress in higher arithmetic, while an express gain will be made in new power of mind and wider capacity of pursuing investigations, not in the science of number alone, but in all the higher sciences in which algebra has a place—astronomy, chemistry, dynamics, mechanics, &c.

Algebra is not merely a representative of mental conceptions and operations, it is an agent by which these conceptions can be marshalled and arrayed, employed and tested. Its symbols express (or at least indicate) whatever idea we place, as it were, within them, and its methods enable us to pursue the course of a process of reasoning with the result of learning the consequence to which it leads. We must, of course, attain a mastery over its language and the meaning of its signs. When we have done this, we may reach forward to higher things.

This is one step in the explanation of algebraic method; but in passing from one system of numeration to another the numerical expression varies in its meaning. This, besides being an inconvenience in particular cases, limits our reasoning to particular examples, and takes away from the investigation its most essential character. It is necessary to render our results independent of all convention founded upon arithmetical models; in other words, we must represent the quantities reasoned upon by such general symbols as the letters of the alphabet. To announce in this way the sum of three numbers we write, $a+b+c$, where a, b, and c are symbols of numbers having no reference to any system of arithmetical numeration.

In all algebraic questions the solution consists of two separate processes; the first seeks to find out, from the numbers given in the question, by which of the four fundamental operations the unknown result may be determined; the second consists in the application of these rules. The first is an algebraical process; the latter is an arithmetical one. The first is completely independent of any system of numeration. It aims entirely at the development of the conditions of the enunciation, in other words, of the relations subsisting among the numbers involved. Let it, for example, be required to divide the number 13 into two parts, such that the first shall surpass the second by 5. Here the second part is equal to the first diminished by 5; or the sum of the parts diminished by 5 is equal to double of the first part, or to double of the first *less* 5. But from the enunciation of the question the sum of the parts is equal to 13, and consequently double the first is $13+5$ or 18. The first part is consequently 9, and the second part is 5 less, that is 4.

We might resolve any other question of the same nature by the same species of reasoning; but in taking a new set of numbers it would be necessary to commence the process anew. By employing symbols we obtain a solution equally general, and applicable to all numbers which may be involved in any question of like conditions. Thus, let a denote the greater of two numbers, and b the less; in applying to these symbols the reasoning employed in the case of 13 and 5, we easily prove that the first part sought is equal to the half of the sum of the two numbers a and b. This sum is $a+b$, and its half is $\frac{a+b}{2}$ which is a general expression for the first part sought. Applying the reasoning to the second part, which the question supposes to be less, we find that it is equal to half the difference of the two given numbers; now, the difference is $a-b$ and the half $\frac{a-b}{2}$, which is an expression for the second part sought. Now, whatever numerical values we give to a and b, it is only necessary to substitute them for their symbols in these expressions to find the values sought.

The simplicity of its language is one great advantage of algebra. Common language might in some simple instances be employed, but in general its expressions are too prolix. Take as an example the enunciation of the following short and simple proposition:—"The greater of two numbers is equal to half their sum increased by half their difference." This, expressed symbolically, *i.e.* algebraically, is brief, viz.—

$$m=\frac{m+n}{2}+\frac{m-n}{2}$$

in which m is supposed to be the greater of the two numbers and n the less. This expression enables us at once to see that the proposition is true; for on the right of the sign $=$ we find $\frac{n}{2}$ once added and once subtracted, consequently it

might, without affecting the truth of the expression, be expunged, leaving $m = \frac{m}{2} + \frac{m}{2}$, that is in effect $m = m$.

Not only does algebra give a facility in seizing upon the conditions, but it reduces the reasoning employed in the operations in some measure to a mechanical process. The grammar of its language is simple and precise, and the signs employed in expressing its relations are very few in number. Algebra is a branch of study from which many are deterred by an idea of its difficulty; no prejudice could be more erroneous. If the student has attained a good knowledge of arithmetic, especially of fractional arithmetic, he has no real difficulty to surmount in the acquirement of algebra. He has simply to divest his mind of the notion that numbers can only be represented by the conventional symbols 1, 2, 3, 4, &c.; these are quite necessary to the expression of quantity when we consider it as composed of determinate units. Numerical symbols are of the utmost importance in expressing with brevity and distinctness arithmetical results; but in the logical investigation of the principles of calculation they are replaced with advantage by other symbols of a more general kind.

It may be as well to illustrate this point in a plain and familiar fashion before proceeding to any systematic exposition of the specific principles of algebraic operations. De Morgan places the contrast between arithmetic as the concrete science of number, and algebra as the abstract calculus of operations, very simply before the mind in the following examples:—(1) If 2 acres let for £13, how much will 17 acres let for? It is easily seen that the number of pounds required is that obtained by multiplying 13 and 17(=£221), and dividing the product by 2 (=£110 10*s.*) (2) If any number of acres (we please to name) cost a certain number of pounds, the price of any other number of acres may be found by multiplying that other number by the number of pounds the first acre cost, and dividing (the product) by the number of the first-mentioned acres. The former is a special instance, the latter is a general rule. The manner in which the latter is translated into algebraic expression is as follows:—We invent short signs to signify that multiplication and division are to take place. We express the one by putting × between the numbers which are to be multiplied, and the other by writing the divisor under the dividend and drawing a line between them. The foregoing rule, then, stands thus—Price, in pounds, of second number of acres is

$$\frac{\text{2nd No. of acres} \times \text{price, in pounds, of 1st No. of acres}}{\text{1st No. of acres}}$$

Here we have abbreviated by using two symbols of operation. If next, instead of any number named in the problem, we were—that we might notice it better—to place a letter where that number appears, we would have a form like this—

$$\frac{\text{2nd No. of acres } (c) \times \text{price, in pounds, of 1st No. of acres } (b)}{\text{1st No. of acres } (a)}$$

Instead, then, of writing the words, let us simply employ the letters which stand for them, and we have—

$$\left.\frac{c \times b}{a}\right\} \text{or as it may be otherwise, and usually is written—} \left\{\frac{cb}{a}\right.$$

Thus the algebraist reduces to the briefest form not only the expression of the problem, but the indications of the process through which it must be passed to find the answer.

Or, to take a case which is more readily brought under the view of the concrete imagination. Supposing that the following problem has been given us to solve—viz. Divide £890 among three persons so that the first may have £180 more than the second, and the second £115 more than the third, how could we proceed to find the answer? It is plain that if any one of the three persons' shares were known the other two could be discovered at once, for (1) if we knew the third person's share we would only require to add £115 to it to find the second's, and £180 to that to find the first's; (2) if we knew the second's share, by adding £180 to it the first share would be found, and by subtracting £115 from the second we should have the third; (3) if we knew the first's share we would merely require to subtract £180 to find the second's, and £115 from that to find the third's. It is also obvious that the third person's share—whatever it may be—(1) if added to £115, would give the second's; (2) if added to £115 and £180, would give the first's; (3) that these three shares added together must equal £890; that is,

$$\left.\begin{array}{l} \text{1. The third person's share,} \\ \text{2. The third person's share, with £115 added,} \\ \text{3. The third person's share, with £115 and £180 added,} \end{array}\right\} \text{equal £890.}$$

Looking at this problem as thus put before us, we see (1) that three times the third person's share and £115, together with another £115 and £180, amount in their sum to £890; that is, in other words, three times the third person's share added to (£115 + £115 + £180) is equal to £890; (2) that if the triple of the third person's share added to £410 is equal to £890, this triple share must be less than £890 by £410; and (3) that if we subtract £410 from £890 we find that the triple of the third person's share is (= £890 − £410) £480. Let us now divide £480 by 3, and the answer (£160) is the third person's share. To £160 add £115, and the second share is discovered to be £275. The first person's share is found by adding £180 to £275, which make together £455. Now, £455 + £275 + £160 make together £890.

The algebraist, in a problem of this sort, proceeds in a different manner. He (1) denotes the third person's share—whatever it may ultimately prove to be—as it is at present unknown, by the letter x. The second person's share (2) is set down as $x + 115$. The third person's share (3) takes the form of $x + 115 + 180$; and they are put down thus—

$$\left.\begin{array}{l} 1.\ x \\ 2.\ x + 115 \\ 3.\ x + 115 + 180 \\ \hline 3x + 230 + 180 \end{array}\right\} \text{which equals} \left\{\begin{array}{l} 3x + 410 = 890 \\ 3x = 890 - 410 \\ 3x = 480 \\ \quad x = 160 \end{array}\right.$$

$$\text{which gives} \left\{\begin{array}{lr} x = & £160 \\ x + 115 = & 275 \\ x + 115 + 180 = & 455 \\ \hline & £890 \end{array}\right.$$

The careful observer will see that the answer $(3x + 230 + 180)$ must equal 890; and therefore the statement may be reduced, by change of signs, to $3x = 890 - 410$; when 410 is subtracted from 890 we have for remainder 480, which gives $3x = 480$. We then divide by 3, which leaves one x as the equivalent of 160, as seen in the second column. The x being found to represent 160, we have only to add 115 to that amount for the second share, and 115 and 180 added to the same sum (160) gives the first share. This is proved to be correct by the whole three—the conditions of the problem having been fulfilled—being found to make up the sum given in the original statement (£890).

If, now, we desired to perform this operation by seeking to find the first person's (*i.e.* the greatest) share first, we might proceed in a similar way. Saying, let the first person's share be denoted by y, the second person's share will then stand as $y - 180$, and the third person's share by $y - 180 - 115$. On these three quantities being arranged in succession they stand thus—

$$\left.\begin{array}{l} y \\ y - 180 \\ y - 180 - 115 \\ \hline 3y - 360 - 115 \end{array}\right\} \text{which equals} \left\{\begin{array}{l} 3y - 360 - 115 = \\ 3y - 475 = 890 = \\ 3y = 890 + 475 = \\ 3y = 1365 = \\ \quad y = 455 \end{array}\right.$$

Whereupon we proceed, as before, to find the other numbers. $455 - 180 = 275$, second share; and $275 - 115 = 160$, third share, making again £160 + 275 + 455 = £890.

Algebra represents the magnitudes with which it deals by symbols which have no intrinsic value, and are, for its purpose, entirely emptied of the idea of value in themselves. The magnitudes which its symbols represent are therefore indeterminate. It is thus capable of taking absolute magnitudes of any nature, real or imaginary, and reasoning regarding them with exact conclusiveness. The results at which it arrives

are quite general, and extend to all the possible values which may be attached to its symbols. It has always been reckoned the mark of a master-mind to be able to see the general in the particular, and to abstract from the particular the general truths it involves. In the stores of general facts collected by laborious observers the man of genius perceives the law of their operation, and distinguishes that from all accidental environments. This he does by taking one element, and working out with it symbolically all that lies within it, and often by the exercise of this mental process magnificent scientific results are attained. Concrete things, regarded as concretes, restrict the mind in its dealings with them to the consideration of their actual perceptible qualities; but these concrete things suggest many ideas of an abstract character to the mind, and these the mind is compelled to symbolize to itself, if it would operate thoughtfully with or upon them. The symbol enables the mind to get free from the restrictions of sensible phenomena and to lift the idea into the region of intellectual consideration. It is an arbitrary mark, indicating a specific conception or idea, and ought in the same process of calculation or reasoning always to retain precisely the same signification through whatever conditions it may be made to pass. Algebra organizes symbolical notation, and enables us to reach truths concerning the ideas expressed by the symbols more clearly and briefly than we could by any other method than this substitution of symbolical equivalents. The compact and powerful processes of algebra appear to be mysterious and ill to understand, principally from the mind being unaccustomed to deal with any other symbolical signs than those of language or figures. The operations of algebra are conducted through this language of symbol.

It will be useful to register here for future reference some of the most common signs and forms of expression employed in the statement and working of problems in algebra.

The word *quantity* is, in algebra, employed as an extension of the word number. In such a phrase as *numerical quantity* its meaning is obvious; thus one-half, though not a number, is a numerical quantity. The word quantity, as a term, has its origin in and its usage determined by the adoption of a *unit* of measure. For example, if the unit of measure be 1 foot, the quantity which stands for the length of a room is an idea of which the mind has a distinct conception, although it may not be an exact number of feet or inches.

Any sum or quantity may be selected as a unit, and then all other sums or quantities must be expressed by numbers or fractions representing the number of times or parts of times such sums contain that unit. Thus, if 3*s.* 4*d.* be taken as a unit, this sum will throughout be represented by 1, or a, while a pound will be denoted by 6, or $6a$.

The expression quantity is also used with reference to the results of operations which are not so readily expressible in signs as the above; such, that is, as instead of calling up an impression, refer the mind simply to the operation. The term *magnitude* is also sometimes used to direct the mind to the immediate contemplation of the particular thing treated of; but, as all algebraical operations depend on comparison or combination, magnitude is not a very convenient term, and we shall not frequently adopt it.

The first point which distinguishes algebra from arithmetic is this, that the number or quantity required is represented in a visible form to the eye. This is usually done by the use of one of the letters of the alphabet, $a, b, c; x, y, z$.

In some instances Greek and even other characters are introduced. Algebraists not only represent the thing sought by a letter, but they very frequently employ a like notation for the things given.

Any quantity immediately preceded by the sign $+$ (*plus*) is called *positive* (and such quantities are to be added).

Any quantity immediately preceded by the sign $-$ (*minus*) is called *negative* (and such quantities are to be subtracted).

A quantity preceded by neither plus nor minus is always regarded as *positive*; thus, a signifies $+a$. The sign $-$ (minus) must always be prefixed to negative quantities.

When one quantity is to be added to another the sign $+$ (plus) must precede the quantity to be added; thus, $a+b$ signifies that b is to be added to a, $a=9+b=3$, $a+6=15$.

When a quantity is to be taken from another the sign $-$ (minus) must precede the number to be subtracted: thus, $a-b$ (the values as above) $=6$.

An expression in which quantities are connected by the symbol $=$ is called an equation; thus, $4+5=8+1$ is an equation; $x+5+3=2x-x+8$, and $x+7=2x-3$ are equations.

The *terms* of an expression are the different parts of which it is made up by addition and subtraction; the *factors* are those of which it is made up by multiplication: thus, a, b, and c are the terms of $a+b+c$, and the factors of $a\times b\times c$. When a compound expression consists of two terms, it is called a *binomial;* when of several terms, a *multinomial.*

An expression involving a symbol, x, is sometimes said to be a *function* of x: thus, x^2, $x+a$, $x^4+4x^3+bx^2+1$ are functions of x. Again, a^2+2a+4 is said to be the same function of a that x^2+2x+4 is of x.

When the product of two quantities is sought, the sign for multiplication ($\times$ or .) must be placed between them. $a\times b$ and $a.b$ each mean a multiplied by b. The most common way of expressing this, however, is by simply joining the symbol-letters, as ab.

When the sign for division, $\div$, is used it precedes the divisor and follows the dividend. Division is frequently denoted by placing the dividend above the divisor and drawing a line between them; thus, $\frac{a}{b}$ signifies a divided by b. $a\div c$ and $\frac{a}{c}$ denote the same operation.

These are the ordinary symbols of operation. They are only the abbreviations for expressing the application of the first four rules of arithmetic.

A *parenthesis* ( ), a *bracket* { }, or a *vinculum* $\overline{\quad\quad}$ denotes that all the quantities which any one of them joins together are affected equally by some other quantities: thus, $(4+6-7)\times 5$, $\{4+6-7\}\times 5$, and $\overline{4+6-7}\times 5$, each shows that the numbers 4 and 6, with 7 subtracted from them, are to be multiplied by 5; *i.e.* that 3 is to be multiplied by 5. The parentheses and the brackets are for the most part employed in uniting quantities for multiplication, and the vinculum in fractional expressions and quantities involving the use of the radical sign.

A figure placed before any algebraical symbol-letter is called the co-efficient of that letter. Co-efficients may be positive or negative. If a letter has no expressed co-efficient, it has 1 understood as its co-efficient. The 1 is usually omitted in stating a question; *e.g.* ac signifies one (1) quantity, a, multiplied by one (1) quantity, c.

A small figure written on the right of a letter or quantity and above the line is the index (or exponent) of the power of this quantity; thus, in 2^4, 4 is the index of the power of 2, and the expression means 2 raised to its fourth power, $2^4=16$. The first power is unnoted; the others are expressed, a^2, c^3, a^4, c^5, &c. And, in general, a^n denotes that the number a is repeated with signs of multiplication as many times as are represented by the number n.

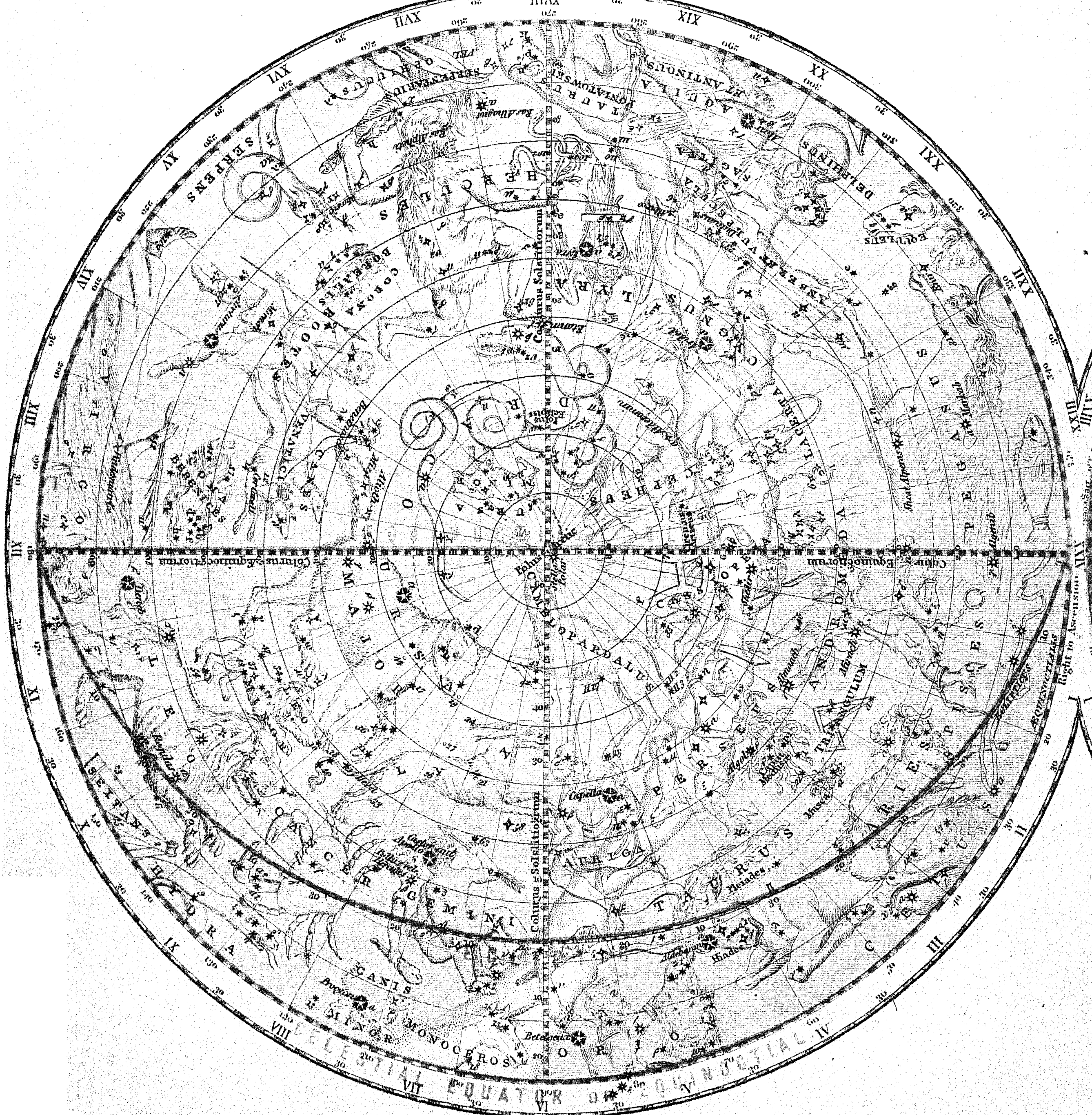
When the sign $\sqrt{}$ precedes any quantity it signifies some root of that quantity, and a small figure written within the sign is the index or exponent, *e.g.* $\sqrt[3]{a}$ signifies the cube-root of a.

The signs $\sqrt{}$ for the extraction of the square root, $\sqrt[3]{}$ for that of the cube root, &c., are frequently used as in arithmetic. Thus, $\sqrt{(a+x)}$, or $\sqrt{\{a+x\}}$, or $\sqrt{a+x}$, signifies the square root of the sum of the two numbers a and x. It must be observed, however, that $\sqrt{a+x}$, $\sqrt{}\,a+x$, and $\sqrt{}\,a+\sqrt{}\,x$, are totally different things; the second represents the sum of the number x and the square root of a; the third the sum of the square roots of the numbers a and x.

The square of a number is represented by a^2. The square root may be in like manner represented by $a^{\frac{1}{2}}$, the cube root by $a^{\frac{1}{3}}$, &c. In this system of notation, a is considered as equivalent to a^1.

There is a very convenient notation for many purposes, which, though it has much the appearance of the expression of powers by indices, is totally different from it. Instead of introducing a new letter to express different quantities, the same letter is employed, and an index figure is subscribed; thus, a_1, a_2, a_3 stand for different quantities not necessarily connected with each other. In the same way, a', a'', a'''.

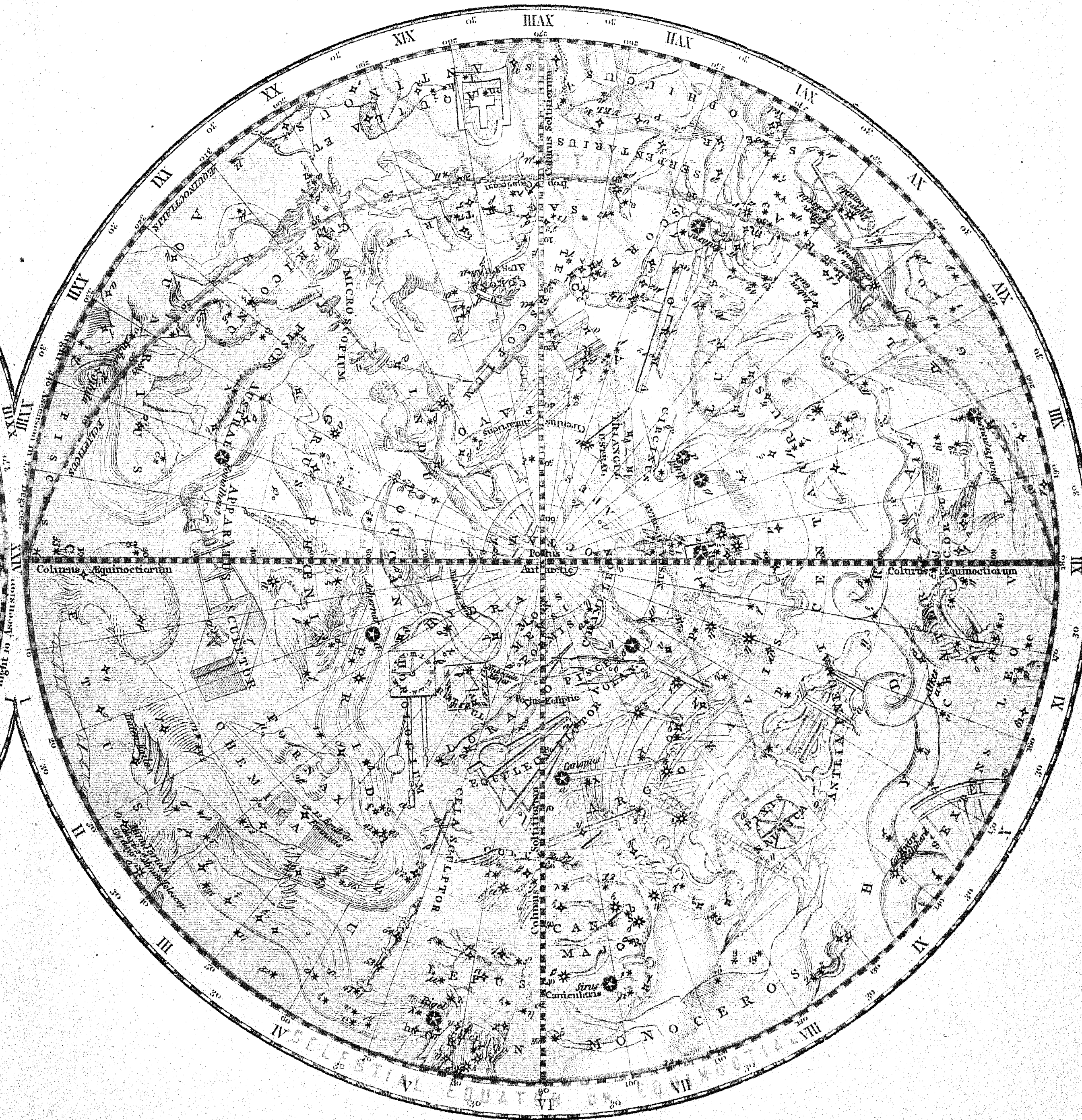
CONSTELLATIONS OF THE NORTHERN HEMISPHERE.



1 2 3 4 5 6

Magnitudes

CONSTELLATIONS OF THE SOUTHERN HEMISPHERE.



1 2 3 4 5 6 Nebulæ

Magnitudes.

${}^1a$, ${}^2a$, ${}^3a$ are used, the latter form not so frequently. This notation is specially adapted to express quantities of the same kind occurring in different positions, and may be read first a, second a, third a, &c.

Quantities in which there are no roots involved are said to be *rational;* thus, $a+2x$ is a rational quantity. When roots are involved they are termed *irrational;* thus $a+\sqrt{x}$ is an irrational quantity. The word *surd* is adopted to express concisely exactly what is signified by the phrase "irrational quantity." When the expression contains two terms, the surd is called a *binomial* surd; when one or both of the terms involves the square root, it is called a *quadratic* surd: thus $a+\sqrt{x}$ is a quadratic surd, $\sqrt{a}+\sqrt{x}$ and $a+\sqrt{x}$ are binomial quadratic surds.

Expressions which involve only one term, as a^2, a^3b, &c., are called *simple,* while those which involve two or more terms are called *compound.* Thus $a+b$, a^2+ab+b^2, $a^5+5a^2b^3-7a^4b$ are termed compound expressions; and those in which the dimensions of each term is the same, as is the case in the examples just given, are said to be *homogeneous.*

Similar or *like* quantities contain the same letters or combinations and powers of letters.

Dissimilar or *unlike* quantities do not contain the same letters or combinations and powers of letters.

The *reciprocal* of a quantity is unity divided by that quantity. There are a few other technical words used to abbreviate expressions, but these the student will learn to make use of by finding them actually employed better than by any verbal explanation.

In arithmetic absolute numbers are given in each problem and employed in each operation, and an absolute number is sought as the result of the processes requisite to work each sum. In algebra the nature of the question, abstracted altogether from any special number, is given, and we are required to find a general method of solving all such questions, and to do so by showing through symbols to the mind what operations must be employed to attain a trustworthy result. The symbols used are not numbers, though they represent numbers. Each may stand for any specific absolute number we place in any question, provided that in the same question it indicates, throughout the whole process, that particular number and nothing else. It is because the symbolic language or the signs of algebra are thus universal, *i.e.* apply to all possible particular cases of that same kind, that its conclusions are universal. In translating the terms of a question into the language of algebra we have to remember that (1) a sign is an arbitrary mark, and (2) each sign has (and must have) only one fixed meaning or signification throughout the course of any one distinct process or operation. We require (i.) a series of signs representative of our conceptions, the subjects of our investigations: these are usually literal symbols, as of *known* things, a, b, c, and of *unknown*, x, y, z; (ii.) signs of operations, as $+$ (plus), $-$ (minus), $\times$ (multiply), $\div$ (divide); (iii.) signs of equality and identity or otherwise, $=$ (equality), $\urcorner$ (greater than), $\angle$ (less than); (iv.) of inference, $\because$ (since), $\therefore$ (therefore). The following self-evident axiom is adopted in regard to algebraic operations :—When any two or more quantities are equal, if any one of them is subjected to any operation which would increase or diminish it, the other (or others) must, if we wish to preserve their equality, be subjected to the same operation of increase or diminution. This axiom may be made more easily available for use by being expressed in reference to special cases. (1) Two numbers remain relatively equal when (i.) the same number has been added to or subtracted from each of them, or (ii.) they have been each multiplied or divided by the same number; and (2) no number is altered (i.) by the addition of any number followed by the subtraction of the same number, or (ii.) by being multiplied by any number, if the product be afterwards divided by the same number, and *vice versâ.*

An idea of the value and utility of these symbols of notation and indications of operation will be gained by solving the following

Exercises.—1. If $a=1$, $b=2$, $c=3$, what is the value of the following algebraical expressions—viz. $a+b+c$; $-a+b+c$; $a-b+c$; $a+b-c$; $-a-b+c$; $-a+b-c$; $a-b-c$; $-a-b-c$? *Ans.* 6; 4; 2; 0; 0; -2; -4; -6.

2. If $a=5$, $b=7$, $c=9$, what results would the same expressions yield? *Ans.* 21; 11; 7; 3; -3; -7; -11; -21.

3. With similar values, what would be the value of $2a-4c+2b$ and $3b+7c-4a$? *Ans.* -12; -56.

4. If $a=2$, $b=4$, and $c=5$, calculate the value of (1) $a+2b-c$; (2) $ab+2c$; (3) $\frac{b}{2}+\frac{c}{3}$; (4) $(a^2+b)c$; (5) a^2+2b-c. *Ans.* (1) 5; (2) 18; (3) $5\frac{2}{3}$ (4) 40; (5) 7.

5. If $a=3$, $b=2$, $c=5$, and $n=2$, calculate the value of (1) $(a-b)\ 5+n$; (2) a^3-b^2+b+a; (3) $(b+c)+a^2$; (4) $\frac{a+c}{2}+b$. *Ans.* (1) 7; (2) 28; (3) 16; (4) 6.

ASTRONOMY.—CHAPTER I.

INTRODUCTION — THE HEAVENS — STAR MAGNITUDES — STAR CHARTS — MILKY WAY — THE SUN A STAR IN MILKY WAY — NEBULÆ — POLE-STAR — CONSTELLATIONS — FIXED STARS — SOLAR SYSTEM, SUN, PLANETS — MOVEMENTS IN SPACE — MOTION OF THE STARS — ORDER OF PLANETS ROUND THE SUN — COMETS — METEORS — MAGNITUDES OF PLANETARY SYSTEM — FIGURE OF THE EARTH — APPARENT DIURNAL MOTION OF STARS — APPARENT ANNUAL MOTION OF SUN — ECLIPTIC — SIGNS OF THE ZODIAC — EQUINOXES — SIDEREAL DAY — SOLAR TIME — MOON'S PARALLAX — MEAN DISTANCE OF SUN — DISTANCE OF FIXED STARS — VELOCITY OF LIGHT TAKEN AS UNIT OF REDUCTION — MOTION OF THE SUN IN SPACE — MOTIONS OF THE STARS — DOUBLE STARS — COLOURED STARS.

THE starry firmament, that limitless ocean which sparkles with a thousand minute points of light, constitutes what is termed the heavens, and the science of astronomy teaches not only the structure of the universe, but the calculation of the distances of the stars and the determination of their movements. To a casual observer the stars appear to be tolerably regularly distributed through space, and the first feature connected with the stars to which attention is directed is their very varied degrees of brightness. On this account astronomers have classified the stars into different groups corresponding to their brilliancy. About twenty of the brightest are said to be of *first magnitude*, among which are *Sirius*, or the Dog-star, the most brilliant star in the heavens, *Capella*, *Aldebaran*, *Arcturus*, &c. Next in order come the stars of the *second magnitude*, examples of which are the four brightest stars in the constellation of *Ursa Major*, the Great Bear. Argelander has computed the number of stars of each of the different magnitudes as follows :—First magnitude, 20; second, 65; third, 190; fourth, 425; fifth, 1100; sixth, 3200: seventh, 13,000; eighth, 40,000; and ninth, 142,000.

Of these stars, however, only a comparatively small number, some 3000, are visible to the unaided eye in England. The stars of the sixth magnitude are so faint that it requires exceedingly good vision to distinguish them, while the number of stars whose magnitudes are lower than the ninth is apparently without limit. Argelander, who has published a series of maps of the stars in the northern hemisphere, from the brightest down to the tenth magnitude, records more than 300,000 stars on these maps. The number of the smaller stars is at present uncounted, for every increase in telescopic power reveals countless myriads, which an inferior power would fail to discover. Thus, it will be noticed that the numbers of the stars of each magnitude increase with very great rapidity as the brightness diminishes; but it should be understood that this classification refers simply to apparent brightness, and that it affirms nothing as to real dimensions, distance, or even intrinsic brilliancy. As the eye more closely examines the heavens a whitish, undecided, vapoury glimmer will be observed stretching across the firmament, somewhat of the nature of a belt, and encircling the whole heavens. This appearance, which is termed, from its appearance, the *Milky Way*, is divided into two principal branches throughout nearly half its entire length; its breadth is very variable, sometimes contracting, at others spreading out. As the borders of the Milky Way are approached the stars appear more and more crowded together, and mostly so small that the eye almost fails to distinguish them. This accumulation of stars in the direction of the Milky Way is apparent

when the heavens are examined with the aid of a powerful telescope; indeed, the faint luminosity of the Milky Way itself arises from myriads of minute stars—that is, of *suns*, for each star, from the most brilliant to the faintest, is a sun, and this multitude of millions of suns is divided into numerous and distinct groups, and our sun himself is only one of the stars of the Milky Way. A still closer examination of the heavens with the naked eye will discover here and there whitish spots resembling little clouds, like so many patches detached from the Milky Way, and termed in astronomical language *nebulæ*. The telescope reveals these by thousands, and the spectroscope and the telescope together have made us acquainted with their formation. The spectroscope proves that many of them are but masses of glowing gas, while the telescope reveals others of these cloud-like masses to be star-clusters. It is in vain to attempt to realize the unspeakable distances which separate these archipelagoes of worlds from ours—unfathomable abysses, which the most powerful telescopes only prove to be lit up by millions of suns.

An attentive observer will soon perceive that the stars seem to revolve in a body around one star situated in the north, a point which appears midway between the horizon and the zenith or point vertically over the head of the observer. This is the *Pole-star*, so called from its being near the pole of the celestial equator, an imaginary prolongation of the equator of the earth. For reasons that will hereafter be explained the present Pole-star (α in *Ursa Minor*) will not always be such. The true pole is now $1\frac{1}{2}$ degrees from this star, and this distance will gradually diminish until it is reduced to about half a degree, when it will increase again, and after the lapse of a long period of time—12,000 years hence—the brilliant star of the first magnitude, α *Lyræ*, which is now 51° 20′ from the pole, will have approached to within less than 5 degrees of the polar point. The present Pole-star can be seen on every clear night. To identify the Pole-star it is necessary to know the constellation of the Great Bear, *Ursa Major*, sometimes called the *Plough* (see Plate I.); the two stars α and β are commonly termed the *pointers*, for they point nearly in a direct line up to the Pole-star (*Stella Polaris*). If the observer carefully notes the position of the seven stars forming part of this constellation at an early hour in the evening, and then looks at them again a few hours later, a remarkable change will be seen: the relative positions of the seven stars have not changed, the outline of the constellation is unaltered, but the entire group has moved bodily in the heavens. The two pointers are still directed towards the Pole-star, and it seems that the whole constellation has moved round that point, and if the observation was continued long enough, it would be apparent that in a trifle less than twenty-four hours the constellation would have described an entire circle round the pole.

From the earliest ages of antiquity it has been the custom to arrange the stars into conventional groups or constellations for the purpose of more readily distinguishing them. Modern astronomers have continued this arrangement chiefly on account of the confusion that would arise were it now to be abandoned. The stars do not undergo, to the eye, any sensible relative change of position in the heavens; their distance is such, that they appear actually at rest in the depths of space; hence the old term of "fixed stars," now abandoned, as a minute study of their relative positions has established the fact that the stars really do move in the remote regions of the heavens. Their apparent immobility is evidenced by the uniformity of appearance preserved for centuries by the groups of stars forming the constellations. Astronomy teaches us that the stars, like our sun, are bodies which shine by their own light and heat, and that their apparent minuteness is only due to the vast distances by which they are separated from us; and when proper allowance has been made for the effect of this distance, it is found that some of these stars are as bright and large as our sun. This has led astronomers to the conclusion that the sun is really only one of the host of countless myriads of stars with which the heaven is bespangled, and that although the sun is to us on the earth vastly more important than any of the other bodies in the universe, yet this importance is due to the comparative nearness of the sun to the earth, and not to any real pre-eminence of the sun among the other bodies of the universe.

The sun is the centre of a group or system of its own, of which the earth forms part. Round this centre of light and heat, but at various distances, revolve more than 100 secondary bodies or *planets*, some of which are accompanied by smaller ones, *satellites* or moons, revolving around their primary planet. These planets not being self-luminous would be invisible to us if the light which they receive from the sun were not reflected towards the earth, making them also appear as luminous points, like so many stars; and such would be the appearance of our earth seen in space at a distance sufficiently great.

A common character distinguishes all the celestial bodies that form part of this group—the solar system; for while the suns composing what is termed the sidereal universe are situated at distances seemingly infinite, the bodies composing this group are so much nearer the earth that their displacements in space may be perceived in short intervals of time, and owing to this apparent motion these bodies received at the outset the name which they have since retained, *planets* or wandering stars. Of these objects there are five easily visible to the unaided vision at the proper seasons for seeing them; the names of these planets are Mercury, Venus, Mars, Jupiter, and Saturn. These were all well known to the ancients, and their movements appear to have attracted attention from the earliest times. An observer who is unacquainted with the heavens might easily confuse the planets with the brighter stars. With a telescope he would at once be able to tell the difference between one of these planets and a star. Through the telescope even the brightest stars are little more than bright points of light, while the planets show a clearly defined disc, and appear spherical or nearly so, and by watching a planet for a few nights and carefully comparing its position with the stars in its vicinity its motion may be detected. It is thus, when an observer stands in the middle of an extensive plain, that distant objects are judged. Those that border the horizon, or limit of vision, are regarded as immovable, while the slightest change of place in the near ones is instantly perceived. When the observer himself moves, then the real movements become complicated with the apparent movements, but the former must be distinguished in order to obtain an exact idea of the actual course travelled. This complication of the apparent motions of the planets, the result of the movement of the earth, is one of the most striking testimonies to the reality of the earth's motion; and it will be seen in the detailed description hereafter of each of the planets of the solar system, what wonderful variety takes place within its limits: movements of rotation, movements of revolution around the common centre, the duration of these movements, distances, forms, and dimensions, distribution of light and heat, all vary; yet with all this variety the same laws govern all.

There is one circumstance common to all the bodies of the solar system that immediately presents itself to the imagination: these enormous masses, the planets, many of which are vastly heavier than the earth, and the earth itself, are not only suspended in space, but move through the ether, the medium which is supposed to fill the void of space, with stupendous velocities. For an instant let the reader imagine himself a spectator standing immovable in space, a luminous speck appears in the distance, little by little it approaches and increases in size; its immense circumference, which exceeds 265,000 miles, is in rotation with a velocity which causes a point on its periphery to travel through 9 miles a second. This vast globe at last passes before you, carried eternally through the depths of space with a velocity of nearly 500 miles a minute. Such is the way Jupiter would appear travelling in its orbit, and such a headlong career would banish it for ever to the most remote regions of the visible universe were it not controlled and held in check by the powerful attraction of a globe a thousand times larger than its own mass, by the sun itself. Now, astronomy shows by undeniable proofs the reality of these marvellous and stupendous movements, and not only determines their invariable constancy, at least during thousands of centuries.

but also demonstrates that their very rapidity is the cause of the stability of all the celestial bodies.

Whatever difficulty there may be in realizing such vast masses careering freely through the ether of space, how much more impressive is the knowledge that these rapid movements are not confined alone to the planets, but that the sun, with all its attendant planets, is moving in an orbit as yet unknown, attracted doubtless by some other sun or group of suns. The stars, which by reason of their infinite distance appear immovable, in reality move in different directions; and in considering the sidereal universe later on, it will be seen that if these movements are performed with apparent slowness, the slowness is apparent only, for they are the most rapid celestial movements known. Hundreds of thousands of centuries will not complete these immense sidereal circuits. It is thus, in contemplating celestial phenomena, that the idea of infinite duration impresses itself on the mind with the same irresistible force as the conception of the infinity of space. Thus astronomy reveals the universe in its majestic whole, and enables us to comprehend its structure and the eternal laws that govern the mechanism of the heavens.

The solar system (see Plate II.) consists of the bodies which revolve round the sun. These are the earth, the planets, and their satellites; the comets, and a vast host of minute bodies which, when they are attracted into our atmosphere, produce the well-known phenomena of shooting or falling stars, also form a part of the solar system. The most prominent member of this group is the *Sun*, the central body relatively immovable, and far exceeding in dimensions all the other bodies of the solar system taken together, round which all the others revolve, self-luminous, and at once the great source of light, heat, and life to the earth. Although the sun appears little larger than the moon to the naked eye, yet his magnitude is nearly 1,251,570 times that of our earth, and 70,000,000 times that of the moon. We get a better idea of this enormous magnitude when we learn that the distance between the earth and the moon is 238,830 miles, and it would take nearly four times this distance to measure the sun's diameter. The nearest of the known planets to the sun is *Mercury*, only one-twelfth part of the size of our globe, 35,392,000 miles distant from the sun, flying around him at the tremendous speed of 109,000 miles per hour, and completing its annual revolution in nearly eighty-eight days. Next is *Venus*, our beautiful morning and evening star. Its size is nearly equal to that of the earth; its distance from the central orb 66,131,000 miles, and its rate of travelling more than 80,000 miles per hour. It takes 224⅗ days to complete its yearly circuit. The third place is occupied by our *Earth*, with its attendant *Moon*, at the distance of 91,430,000 miles from the sun, around which it rolls at the rate of more than 68,000 miles per hour, accomplishing its annual revolution in 365¼ days. The small planet *Mars* occupies the fourth place, about one-seventh the size of our earth, at the distance of 139,312,000 miles from the sun, travelling at the rate of 54,000 miles per hour, and performing its annual circuit in 686 days 23 hours. Between Mars and the next large planet, Jupiter, there have been discovered hundreds of small planets, called *asteroids*—*Ceres*, *Pallas*, *Juno*, *Vesta*, *Astræa*, *Hebe*, &c. They travel at various velocities, and their orbits are very eccentric. They are all, with possibly one or two exceptions, invisible to the naked eye; the diameters of most of them do not exceed 200 or 300 miles. The discovery of these planetary bodies, of which the first was discovered on the first day of the present century, has given rise to an entirely new department of astronomy.

Outside the group of asteroids are found the colossal members of the system of planets—*Jupiter*, with his four attendant moons, being next in succession. It is by far the largest planet in our system, being more than 1300 times the size of our globe, at the distance of 475,693,000 miles from the central luminary, travelling at the rate of nearly 29,000 miles per hour, and requiring almost twelve years to complete his revolution round his mighty orbit. The beautiful planet *Saturn*, with his rings and satellites, next arrests our view, at the distance of about 872,134,000 miles from the sun, and more than 1000 times the magnitude of our earth. It travels at the rate of 22,000 miles per hour, and takes twenty-nine and a half years to accomplish its circuit. Far beyond the orbit of Saturn, just visible to the naked eye from our globe, 1,753,851,000 miles distant from the sun, we find the planet *Uranus*, attended by several moons. Its size is eighty times that of our earth; its rate of travelling is 15,000 miles per hour, and it does not complete one revolution round its orbit in less than eighty-four of our years. Extending our gaze 1,000,000,000 miles beyond the orbit of Uranus, at the distance of 2,746,271,000 miles from the sun, we see, with a telescope, another planet. *Neptune*, attended by one moon, about twenty-one times the mass of our earth, travelling at the rate of about 12,400 miles per hour, and requiring 164 of our years to complete one of its mighty revolutions round our central luminary. The distance of the planet Neptune from our earth is so great that we can form no accurate conception of it in our mind—2,746,271,000 miles! All these planets revolve round the sun at various distances, though in the same direction. Their orbits are all elliptical, and are known to depend on distinct laws, which have been made the matter of much reflective thought and minute calculation by Kepler and Newton. The planets may be regarded as consisting of three groups—(1) four of moderate size, near the sun, of which, in the order of distance, our earth is the third; (2) a large number of small planets (the asteroids), amounting to hundreds, revolving between the orbits of Mars and Jupiter; (3) four of great magnitude, beyond the circuit of the asteroids. The first four are designated the *inferior*, the last four the *superior* planets; the middle series are called the *minor* planets. The inferior planets appear to us on the earth to oscillate about the sun, sometimes moving eastwards *to*, and sometimes westwards *from*, that great "light." The superior planets move round and round the sun—always westwards from him.

All the movements of this solar system are performed with periodical regularity. Those heavenly luminaries which compose it have revolved for countless ages through the marvellous expanses of celestial space with unerring precision. This precision has enabled astronomers to calculate and foretell the condition and position of the planetary orbs. In this way they can by forecast discern what appearance the face of the sky will present many years hence, and can calculate for thousands of years back, with unfailing correctness, the phenomena of the stars at given times.

The *comets*, which also form part of our solar system, frequently appear as a star, the nucleus of which is surrounded with a nebulosity more or less brilliant, and the body is frequently accompanied by a train, the length of which varies in each comet, or in the same comet at different times. This luminous train is called the *tail*. Like the planets, they revolve round the sun, traversing space with very variable velocities, generally in extremely elongated orbits. The *meteors* also move round the sun in rings composed of myriads of these bodies, circulating like the larger planets. It is when our earth in its orbit breaks through one of these rings, or passes near it, that its attraction overpowers that of the sun and causes them to impinge or enter our atmosphere, when their motion being converted into heat and light, they become visible to us as meteors or shooting-stars, according to their size.

Immense as is the stupendous space thus seen to be occupied by the single system of star-groups to which our planet belongs, it shrinks almost into nothingness when we reflect that beyond the circle of Neptune's orbit are millions of stellar bodies, whose movements are so vast that they are beyond our grasp. Even before the erection of the Rosse and Newall telescopes the students of the stars had swept the fields of space to an extent of nearly 10,000,000,000,000 miles, and widened as the bounds of vision have been by higher instrumental power and keener and more careful observation, new forms of beauty still present themselves across these spaces to catch the watcher's eye and give new problems to astronomical science.

In Plate II. a comparative view of the *magnitudes* and relative *distances* of the planets from the sun is given. The magnitudes of the planetary system may be simply illustrated by taking a globe a little more than 2 feet in diameter, to represent the sun. Mercury would then be

represented by a grain of mustard seed 82 feet distant, Venus by a small pea 142 feet, the Earth by a larger pea 215 feet, Mars by a large pin's head 327 feet; grains of sand of varying smallness, spread abroad at a distance of between 500 and 600 feet, might represent the asteroids; Jupiter, at a quarter of a mile distance, might be represented by a moderately-sized orange; Saturn by a small orange, two-fifths of a mile off; Uranus by a large cherry, or a small plum, three-quarters of a mile away; and Neptune by a good-sized plum at a distance of $1\frac{1}{2}$ miles. By extending this elementary scheme the *aphelion*, or greatest distance from the sun, of Encke's comet would be at 880 feet, the aphelion distance of Donati's brilliant comet of 1858 at 6 miles, and the nearest *fixed star* at 7500 miles. According to this scale the daily motion of Mercury would be 3 feet; of Venus, 2 feet; of the Earth, $1\frac{2}{3}$ feet; of Mars, $1\frac{1}{2}$ feet; of Jupiter, $10\frac{1}{2}$ inches; of Saturn, $7\frac{1}{2}$ inches; of Uranus, 5 inches; and of Neptune, 4 inches. These figures illustrate also that the velocity of a planet in its orbit decreases as its distance from the sun increases.

It will be interesting at this point to examine a little more closely in a general way the form, motions, and physical phenomena of that planet which most concerns us — the Earth. To an ordinary observer the surface of the earth presents a very wide contrast to the appearances presented by the sun and moon, for while the earth appears to be more or less a flat plain, the sun and moon have a spherical form, and while the earth appears to be at rest, the sun and moon are apparently in continual motion. If, however, the observer could be situated in space, the form of the earth would appear nearly that of a sphere. This circular form of the earth is never seen except during an eclipse of the moon, when the earth being between the moon and the sun the shadow it throws is then seen on the moon's disc, and as the edge of this shadow is always a part of a circle, it follows that the figure of the earth, which casts that shadow, must be spherical. Careful measurement has shown that this sphere is spheroidal; that is, flattened at the poles, the equatorial diameter being slightly in excess of the polar diameter. The apparent diurnal motion of all the stars with the sun, moon, and planets round the earth, from east to west, is due to the rotation of the earth on its shortest or polar axis once in every 23 hours 56 minutes 4 seconds, from west to east. This apparent diurnal motion of the stars is not, however, the only motion that has to be considered, for the sun himself appears to move among the stars, and his position is in a condition of continual change; for it must be apparent to even the most careless observer, that in summer time at noon the sun is high in the heavens, while in winter his position is low. On the other hand, every star reaches the *meridian* (an imaginary great circle of the heavens passing through the zenith and the poles) at the same altitude, whatever be the period of the year. Consequently the polar distance of the sun is greater in winter than in summer, or, which is the same thing, the *declination* (or its angular distance from the equator) is continually changing; in addition, the sun has an apparent annual motion from west to east. This apparent annual path of the sun in the heavens is a great circle, and is called the *ecliptic*, and the constellations, or groups of stars which lie along its track, and through which the sun apparently passes, are termed the *signs of the zodiac*. The ecliptic is inclined to the *celestial equator*, another imaginary circle in the heavens, in the same plane as the earth's equator, at an angle of 23° 17′, and each point on the ecliptic corresponds to a certain day in the year; that is, the day on which the sun is situated in that point of its annual path. The two points where the ecliptic intersects the equator are called the *equinoxes*, and when the sun is in either of these points day and night are of equal length. The period of the rotation of the earth on its axis constitutes what is termed the *sidereal day*, which is divided into twenty-four hours, each hour into sixty minutes, each minute into sixty seconds; and the great convenience of sidereal time is that each star is on the meridian every day at the same sidereal time. For the ordinary purposes of life sidereal time would not be convenient, and therefore time is calculated by the sun, ordinary clocks being at noon when the sun is on the meridian. This moment of culmination of the sun as shown by a sidereal clock would be different every day on account of the apparent motion of the sun from west to east among the stars, so that, compared with the stars, it would be on the meridian about four minutes later every day. The mean-time clock is therefore regulated by the sun; the sidereal-time clock is regulated by the stars. The mode of determining the mean solar day and the equation of time will be fully explained later on.

In order to obtain precise knowledge of the movements of the heavenly bodies, it is necessary to ascertain the distances by which they are separated from the earth. In the determination of the moon's distance from the earth two simultaneous observations of the moon's apparent position, in relation to a certain fixed star, are made at places widely distant on the surface of the earth. As the stars are so infinitely distant from the earth that all lines drawn from different points of the earth towards the same star are parallel, if the edges of the moon and the star are in a line at the moment of observation at one station, the angle formed between the moon and the star (or the distance the moon is separated from the star), by simultaneous observation at the other station, gives what is termed the *moon's parallax*, from which, as the radius of the earth is known, its distance may be ascertained.

The determination of the distance of the earth from the sun is a matter of considerable importance, as it forms the standard of all astronomical measurement. One of the methods employed is that of the transit of Venus across the sun's disc. For a long period the sun's mean distance from the earth was computed to be 95,293,055 miles, but by further observations made within the last twenty-five years the sun's parallax has been redetermined, and the sun's distance amended to 91,430,000 miles. Great as is this distance of the sun from the earth, it is as nothing compared to the distances of the fixed stars, and could a parallax be determined the distance of the star could be inferred; but, owing to the immensity of their distance they do not exhibit a sensible parallax. It follows that the absence of parallax can only be ascribed to the fact that the stars must be placed at such distances from us that, comparatively speaking, the earth's orbit, which has a diameter of 183,000,000 miles, becomes utterly insignificant, a mere point, when considered in reference to the distances of the stars themselves; and from this circumstance it is inferred that the star in the universe nearest to the solar system is at a distance from it at least 206,265 times as great as that of the earth from the sun, or 206,265 × 91,430,000 miles, which gives the stupendous minimum distance of 18,858,800,000,000 miles or nearly 19,000,000,000,000 miles. The meaning of these figures is, that such in every direction are the dimensions of the space devoid of stars which surrounds our solar system.

In order to deal with such numbers it becomes necessary to seek for units of proportionate magnitude to bring such quantities within reasonable limits. The motion of light supplies one of the most convenient units. It is known that light moves with a velocity of 186,380 miles a second. If, then, the above distance be divided by the velocity of light, the quotient will be the time expressed in seconds which light takes to travel over that distance, and reducing this into hours, days, and years, it is found that light would take three years seventy-four days to travel from the nearest fixed star to the earth, and from the Pole-star half a century is needed.

It will now be understood how impossible it is for stars to shine by reflected light, for at the distance of the nearest star our sun would shine only with the brilliancy of the Pole-star, and the light a star would receive from our sun would only be equal to that received by the earth on the darkest nights, when but a single star pierces through a rift in a thick stratum of clouds; but even this feeble glimmer would require again to traverse the immense distance which separates the star from the earth before it reaches us, twinkling and brilliant, as we see it; and on this ground alone, which supplies most incontestable evidence, the stars are suns, each of them a focus of light and heat, and probably the centre of a system which comprises, like ours, planets, satellites, and comets.

Motion is the common law of all bodies; not only in the solar system are the planets and satellites all endowed both with a movement of rotation round their centres, and with a movement of revolution round the common focus, but the sun also turns on his axis in about twenty-five days, and the comets likewise possess rapid movements which carry them into space beyond the limits of the planetary system. Astronomy demonstrates that the sun, with all his numerous retinue, also moves through space in some unknown orbit, with a velocity of 153,000,000 miles in a year, or about 4 miles a second. The same law of motion probably applies to all the other suns or stars, and the movements of a number of them have been ascertained both in regard to direction and velocity. The bright star Arcturus, in the constellation Boötes, has an apparent motion which requires 100 years to traverse only the eighth part of the diameter of the moon. The real velocity which this apparent motion represents is not less than 197,000 miles an hour, or 54 miles a second; thus the stars, at one time supposed to be immovable in the heavens, are in perpetual motion, many of them with a velocity exceeding that of the planetary bodies of the solar system. The velocity of the movement of Arcturus is three times greater than the speed of the earth in its orbit. The perfection of the telescope has revealed another phenomenon in the observation of the stars. Many of those that appear to the naked eye as points of light are found to be double stars, and an examination with higher powers resolves again each of the compound stars into couples themselves, so that the star which appeared single to the naked eye becomes quadruple with a powerful telescope. The star catalogues now contain over 6000 double stars, of which at least 650 are believed to possess systems revolving round a common centre of gravity. The mean distance from each other of some of the two stars which compose double stars is not less than 1,019,000,000 miles, a distance comprised between the orbits of Saturn and Uranus, and others are separated about forty-five times the distance of the sun from the earth, or more than 4,275,000,000 miles; but these immense distances are lost to the unaided vision: only a powerful telescope can divide them.

Some stars present a coloured light, green, blue, red, violet, orange, yellow, as well as white. Such diversity of tint can only be attributed to the real differences in the nature of the light emitted by each sun. Some stars, again, as Sirius, change colour. Ages ago it was a red star; now it is of a brilliant white. The cause of the colour of the stars and the changes of tint they undergo are at present undetermined.

Having thus sketched briefly the celestial bodies in the sidereal and solar systems, the members of that group of which the earth is one of the constituent molecules will be more particularly noticed, commencing with the sun, as the centre of movement of all the celestial bodies of the solar system.

PENMANSHIP.—CHAPTER I.

Penmanship is at once a fine and a useful art. In its higher developments it passes into the region of artistic achievement, though in its common form it is quite within the scope of the most ordinary powers. It is the means of registering and communicating thought—the power

"Of painting speech and speaking to the eyes."

Lord Chesterfield said that "any man who has the use of his eyes and his right hand can write whatever hand he pleases." Though this is a current, it is not a correct idea. All eyes do not see alike; all hands are not equally deft. There is an individuality in each person which reproduces itself in writing, and is perceptible in each signature. It is true that writing greatly depends on the power of imitation; but though that is the case, imitation of form is much less active and accurate in some than in others. To some, writing is an irksome mechanical task; to others, it brings a joy and imparts a pleasure to which no words can give expression. While we do not entirely agree with the maxim of the too-much-bepraised letter-writer "when George the First was king," we think that it is quite within the compass of any one who possesses ordinary powers of muscular movement and healthy organs of sight to acquire a free, regular, legible style of writing. The formation and combination of the letters of the alphabet into words and sentences require care and perseverance, and the exercise of these qualities in the practice of any art usually results in the attainment of skill. The attempt, however, to reduce the penmanship of men to one same style and system, in which uniformity of product destroys all the personal characteristics of the writers, is one which we do not deem it advisable to make. It is indispensable that men who write should do so legibly; it is not indispensable that all distinctiveness of autography should be obliterated. We shall impress upon our readers the acquirement of the form of letters in a scientific and a systematic manner; but we shall not commend a slavish reproduction of the style or method of writing "given under our hand."

Penmanship is representative speech. As speech ought to be clear, distinct, and audible, writing should be visible, plain, and readable. It cannot otherwise convey its message to the mind. What stammering and stuttering in conversation or reading are, so is illegibility in writing. A fine, plain, easily-read style of handwriting is—without figure of speech—really a series of letters of recommendation.

What constitutes legible writing? A legible style of handwriting is one which can be read easily, pleasantly, and without painstaking; illegible writing involves hesitancy, trouble, and perplexity. Business men regard as a matter of prime importance that writing should be clear, plain, elegant, and above all readable, and very few look with pleasure on the reception of caligraphic riddles through the post. When the style of handwriting is uniform, straight, equidistant in its spaces, and well-proportioned in the shape and size of the letters, as well as symmetrical in the manner of forming all their component parts, it is pleasant to look at and easily read; but when it straggles irregularly along the line, and the letters are different in form when they recur, or vary in size and inclination, penmanship is unpleasant to the eye and troublesome to read.

Penmanship is an imitative art. It requires the conjoint culture of the eye and of the hand. The eye must be taught and brought by habitual exercise to perceive correctly and to convey to the mind precisely the forms presented to it; the mind must be trained until perfect facility is attained to perceive exactly the simple elementary parts—strokes, curves, turns, joinings, &c., by which these forms are represented, and of which the representation of them is made up. These elements the mind must next communicate to the nerves and muscles of the arm and hand as things the reproduction of which, individually and in combination, requires to be thoroughly mastered by them—so thoroughly that, on the mere expression of the will or under the impulse of inclination, they can be at once formed freely and pleasingly. At the bidding of that same will, or on the arising of any necessity, these same elements must be able to be expressed in such combinations as shall form letters, words, and sentences. The whole art and mystery of writing really consists in acquiring skill in shaping properly fifty-two forms—twenty-six small and twenty-six capital letters. These have many elements in common, so that when they are analyzed and reduced to those lines and signs which are recurrent in them they are very few. The habit of forming correct and well-shaped characters is gained, like all other habits, by frequency of repetition; after a sufficient number of repetitions—differing slightly in different persons, however—a habit becomes confirmed into ability or art. The craft of penmanship is mainly learned by having (1) good guidance and (2) good example—guidance in the best way of holding the hand and the pen, of forming and joining the letters; and examples in the free, pliant, and regulated motion of the hand, and in the careful, accurate, and systematic reproduction of those forms which constitute the alphabet and contain within them the whole art and mystery of penmanship. Good training and sedulous imitation are the main means of success in the attainment of the clerkly skill of a ready writer.

Penmanship requires that the eye be trained to perceive precisely the form before it, to analyze it into the elementary lines of which it is made up, to observe their relations and

connections, and to realize them when reproduced. This implies accuracy of vision and critical exactness of sensitive impressions; and supplies the indispensable capacity for taking a complete and thorough survey of what is to be copied or produced, as well as the representative memory required in the reproduction of known and familiar forms. Besides the distinct perception of the eye, writing demands the diligent culture and persevering training of the muscles of the arm, wrist, and fingers. The hand must be made deft by practice. All the complex movements of the hand and arm must be wrought into suppleness and obedience. The nearest and neatest approach to the reproduction of the original—seen by the eye or perceived by the imagination—which forms the type and exemplar, must be made, and that is only to be effected by dexterous sinuousness of movement. That distinct and palpable picture of a letter which passes through the eye into the mind may be clearly and cleverly photographed in the mind, but unless the will control the muscular fibres of the arm and hand, and constrain them peremptorily to imitate and reproduce, the work cannot be done. Training, the result of continued and careful practice, will render the muscles supple and make their motions precise. When eye and hand are rightly taught, when they have brought both of their capacities to simultaneousness of operation, and have been wrought into harmony and concert in effort, penmanship must accomplish its graceful and useful toils with gratifying results.

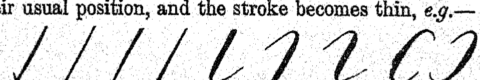
We propose to present to the student some instructions which may be used to regulate the requisite practice and guide the training necessary to gain the certainty and elegance of touch which are likely to make the handwriting produced by them satisfactory and gratifying.

Even in passing the eye along the arranged series of letters forming an alphabet, one can readily see one or two things worthy of attention. It is, for example, pretty obvious that the forms of letters must depend very considerably upon the material used for writing on, as well as on the instrument employed to write with. If the material is hard, like stone, and the writing is to be inscriptional, straight lines will be easier than curved ones, and are therefore likely to be preferred. The lines, too, will most easily be made in a moderately thick style. If, on the other hand, the material used affords a surface fitted for being painted over, as it were, curves are likely to prevail over straight lines, and lines are likely to be bold and thick when sloping downwards, thin and fine when taking an upward direction. On such a surface, again, the desire for rapidity would lead to the adoption of such forms of letters as would permit the meeting together and joining of different lines with the least possible raising of the instrument made use of from the surface. Another step would be the securing of the neatest and readiest connection of different successive letters, proceeding at length to the attainment of a cursive or running style of writing. Ease, utility, and speed being acquired, the love of the beautiful would lead to the culture of a daintiness of execution calculated to charm, and a disposition to ornamental if not fanciful forms of penmanship. Elegance of form, gracefulness of curve, outline, and sweep, and fineness of finish are all highly desirable; and so long as they are not striven for or attained at the expense of legibility, are legitimate objects for the exercise of care and taste. Legibility or distinctness is the first quality in good writing. It is that writing may be read that it is taught or learned. Hence legibility is indispensable. Next to that, perhaps, should be placed easiness of execution, facility of formation, readiness of cursive production. These would greatly tend to the attainment of the quality of rapidity—speed of running over the page with a light and lissom fleetness. Grace of style is a high merit in writing; it adds loveliness to legibility, and gives attractiveness to the results of penmanship.

The elegance and beauty of penmanship depend greatly on the convenience and easiness of the position of the body while engaged in writing. It is quite possible for differently constituted people to write equally well in greatly different positions. There is probably no one definitely best system of sitting suitable to, and that ought to be made imperative upon, everybody. The usual habits of persons in sitting, the manner in which their muscular system has been developed or neglected, the custom of reading pursued by different persons, the capacity of the chest, the state of the spine, all affect the ease of the pose of the frame, and therefore influence the choice or inclination in regard to a position while writing. There are of course certain things which ought to be attended to, whichever position may be adopted. The chest ought not to be pressed against the desk, no stoop of the shoulders ought to be acquired, and the general equilibrium of the body should be carefully preserved. The position on the seat must be firm and steady, but unconstrained; the feet ought to be placed supportingly under the body, and be kept at rest. The left hand should be placed on the nearest corner of the paper or copy, and the weight of the body should be slightly laid on the left arm. That is best managed by keeping the left elbow off the desk and close to the side, so as to supply a steady support for the weight rested on it. The elbow of the right arm should be kept near the body; the right hand, with the pen held properly in it, should be laid lightly on the paper, so placed as to make the required slope in the writing by a natural and unconstrained movement, while the pressure of the fingers on the pen ought to be just enough to retain it steadily in position. A little patience and perseverance given at first to the acquisition of an easy convenient attitude and mode of writing will be amply repaid by the pleasure of progress. Supposing the body to be seated in a comfortable, steady, convenient position, we have next to attend to the holding of the pen, the movement of the fingers, and the motion of the arm.

The pen, as an instrument used for writing with ink, is now made either of the quill of the feather (Lat. *penna*) of some large fowl, as the goose, or more generally even of metal. In ancient times reeds were split and shaped to a point as our pens are, though sometimes a fine hair pencil was employed to paint the letters. Quill pens came into common use after the introduction of modern manufactured paper. Their great defect was softening by the ink, and wearing away with the movement over the rough surface. They required frequent mending, and great skill was needed to give them uniformity of quality. The spread of education, the extension of commerce, and the felt want of some kind of instrument of a cheap sort, which would be ready to the hand of even the unskilful without trouble in the making or mending, led to the introduction of the steel pen. At first it was as closely as possible an imitation of the quill. It consisted of a long barrel of thin steel formed to a point, and cut and slit like a quill. Such pens were at first found to be hard and scratchy; but they are now, by dint of thought, artistic skill, and excellent machinery, produced in forms to suit every requirement of the penman. These fine sheet-steel made pens are thin and compact of fibre, excellently tempered, freely elastic, slit with extreme nicety so as to cut the nib into two accurately similar teeth sufficiently sharp to form the most delicate hair-strokes, and so smooth as to glide readily over the surface of the paper. Some are made of gold, some are pointed with iridium to make them durable, and most of them are fixed by a clasp or holdfast into a convenient handle or holder.

The strokes made by the pen are either light or shaded. Light or hair-strokes are formed by moving the pen lightly, without pressure such as will spread the teeth of the nib. Shaded strokes are made by pressure on the pen more or less heavily, as may be required, to spread the teeth of the nib, and give the required thickness of stroke or shade. By releasing the pressure, the teeth close again and return to their usual position, and the stroke becomes thin, *e.g.*—



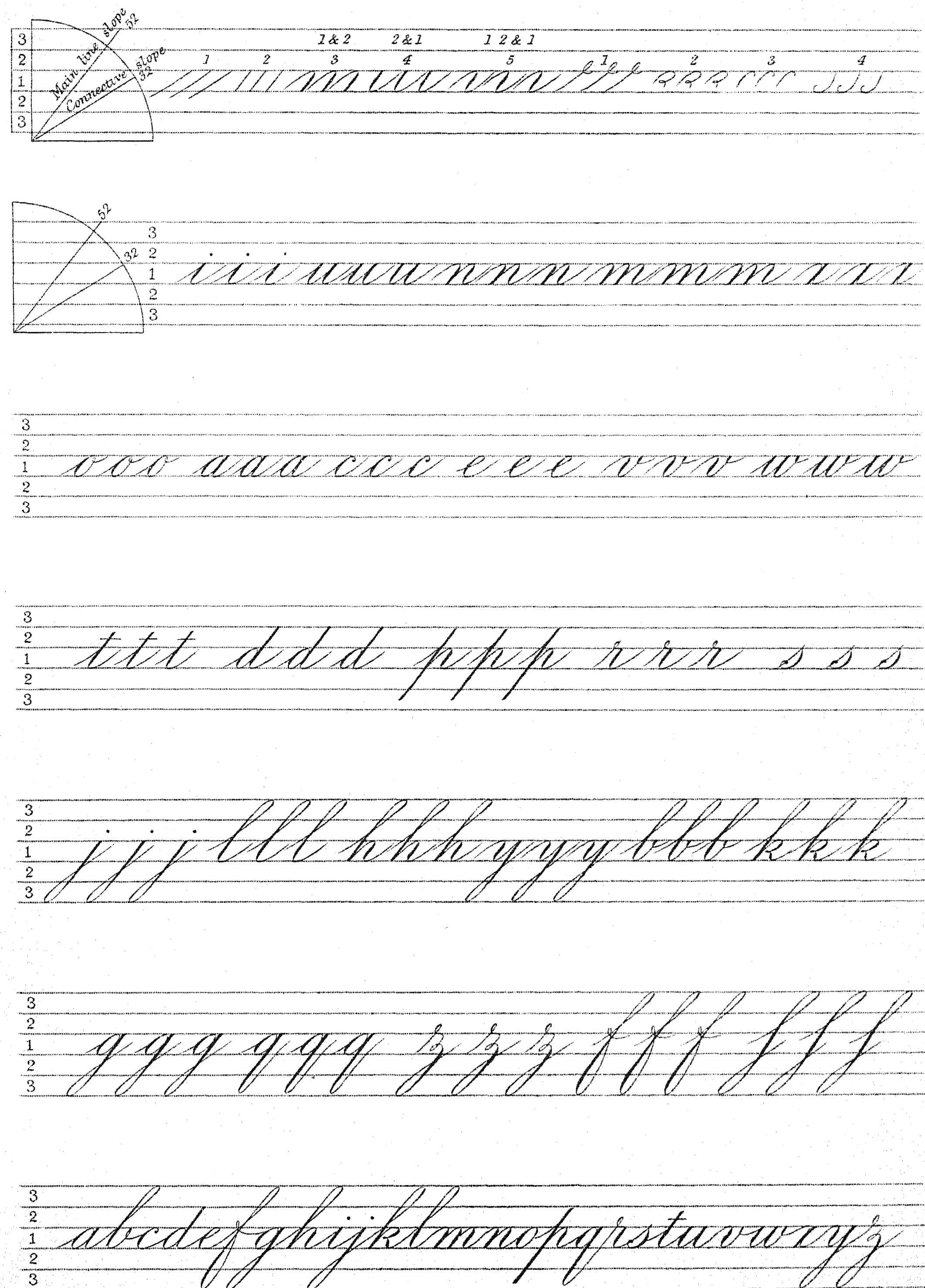
The laws of shading will form a special topic for consideration.

I. *The Movements of the Fingers.*—The first and second fingers and the thumb are used, for the most part, in making the *up* and *down* strokes in writing. The pen is to be taken between the first and second finger and the thumb, at a distance of about $1\frac{1}{2}$ inches from the point of the nib. It

PENMANSHIP,

PLATE 1.

SMALL LETTERS.



is then to be so placed that it lies along the side of the nail of the second finger, in the hollow formed by the meeting of the two fingers. Next it is to pass transversely across the front of the first joint of the first finger, opposite to which the thumb grasps the pen, while the holder passes up so as to rest in the inner hollow of the upper joint of the forefinger. Meanwhile the hand is to be rested lightly, ready for movement, on the nails of the third and fourth fingers, so that the hand may slide as the arm moves across the page and the writing progresses. The pen must be so held that its points come down squarely flat on the surface.

II. *The Movements of the Arm.*—The forearm, when rested on the writing-desk or table, uses that as a fulcrum on and from which it moves to the right or to the left, as may be required, with a sliding or gliding motion of the whole hand on the nails of the third and fourth fingers. Its movements may be regarded as curved strokes. Many excellent penmen use no finger movement at all in writing, but hold the fingers straight and stiff, making all the movements required in the formation by the free motion of the hand at the wrist, while the hand is steadied and directed by the tips of the third and fourth fingers carrying the hand progressively along towards the right.

In writing both sorts of movement are generally combined. The forearm, acting as a centre of motion, carries the hand easily along from left to right, using the nails of the third and fourth fingers as agents in its progress, while the first and second fingers, by their alternate flexure, extending and contracting, as the formation of the letters requires their doing, completes the mechanical activity of the caligraphic art.

ON THE FORMATION OF THE SMALL LETTERS.

There are five simple small letters formed by (1) angular connective strokes, (2) by main slanting lines, and (3) by oval connective turns; these are *i*, *u*, *n*, *m*, *x*.

1. The letter *i*, which is the normal unit of measure, from which we calculate the height of all the other letters in a similar piece of writing, is formed by making (1) a connective light up-stroke the whole height which the main body of the writing is intended to be; (2) a main slanting heavy down-line, forming an acute angle with it; and (3) an oval connective turn—to which add (4) a dot over the main slant-line at a distance of two-thirds of a letter's height from it, e.g. *i*.

2. The letter *u* is formed by (1) making an *i*, without the dot, and adding to that the two central elements of *i*, viz. a main heavy slanting down-line and a connective turn; in short, by forming *i* twice over without the dots, e.g. *u*.

3. The letter *n* is formed by (1) an upward connective stroke, continuing into (2) an oval connective turn, and (3) a heavy main slant down-line; (4) another upward connective stroke, issuing from about the middle of the down-line, continuing again into (5) an oval connective turn; (6) a heavy main slant down-line; and (7) an oval connective turn; in point of fact, a *u* reversed: *n*.

4. The letter *m* is formed in the same way as *n*, except that processes 4, 5, 6 are repeated; thus, *n*, *m*.

The letter *x* is most easily formed by (1) executing processes 1, 2, 3 of *n*, and curving to the left; then upon the form gained, by (2) tracing the letter *c*.

In all these five letters the main slant-lines ought to be equal and parallel, the curves of the connective turns similar and equidistant, and where there are similar angular or curvilinear joinings their angles should be equal.

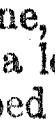
Exercise.—Write according to the directions and examples given the following words:—inn, nim, mim, mum, mix, minx, minim, minimum, unmix, mim-minx, ixum, nixum.

Another series of small letters are formed by combinations of the elements employed in making these five, by adding a variety of small connective circles, such as we see in the letters *v*, *w*, *r*, *z*. This connective is formed by turning at the top of an up-line, towards the left, a small circular loop, to which, on the right, there is attached a small horizontal curve. It occupies about the fifth part of the length of an *i*. (See Plate I. line 1.)

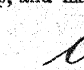
2. Another small connecting loop is that seen in *s*, which is formed by turning the faint up-stroke towards the left and crossing that up-stroke before forming the downward curving line characteristic of the letter. (See Plate I. line 1.)

3. We find a curve of a different sort in *k* and in the lower part of *z*. This is made by turning the line towards the left and making a small circle upwards and to the right, about the middle of an *i*-space.

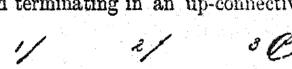
Many writers find it more convenient to use connectives of a dot rather than of a circular character. The directions required are really the same, only that there is no need for opening the circles visibly. Adding these small connective curves (or dots) to the foregoing elements, we have the following letters simply produced—viz. *v*, *w*, *r*, *s*, *z*, and, with their assistance, we form besides *b*, *f*, *k*, as will be seen more clearly when we have treated of oval-shaped and long-looped letters.

To form the letter *v* easily we only require to make the first half of *u*, namely *i*, and to add to that the connective curve at the top, e.g. *v*. If to a fully formed letter *u* we add the connective curve, *w* is formed, e.g. *u*, *w*. In the letter *z* we begin with the connective curve which is formed twice at the height of the letter *i*; from the second curved connective we draw a slanting down-stroke, and repeat the double curve on the base line, *z*; or, instead of the second lower curve, we may give it a looped ending—thus, —after we have learned to form looped letters.

Of an oval or egg-shaped form, in whole or in part, there are several letters. These ovals may be of two kinds—(1) direct; (2) reverse. In the former we begin at the top and move the pen downward with a curve towards the left, to form the left side, and with an upward curve towards the right, to form the right side:  in the latter we either begin at the base-line, making a curve towards the left and rounding towards the right, or, commencing at the top, take a heavy curved line towards the right, and rounding at the base-line to the left proceed towards the starting-point again: 

The normal oval in small letters is *o*. It is begun on the base-line by a slight upward connective slant reaching the height of an *i*; we then carry back the pen in a curve towards the left to the base, turning towards the right with a curve-line, meeting the previous one at the top, and make a short horizontal connective curve to the right: 

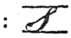
Formed on the same normal model, *a* is next in order. Make first the oval of *o*; to this, at the right side, add the form *i*, without the dot: 

A small *c* is made by taking a slight connective up-stroke from base-line to top; upon that line bring back the pen about a third of the height of an *i*; form there a dot, and from that proceed to take a curve-line, rounding at the top towards the left, and terminating in an up-connective slant, in this manner, 

A small *e* is formed much after the same fashion, except that no dot is made. There is (1) the upward connective slant; (2) the curve to the left; and (3) the upward connective slant stroke:

The letter *r* is formed by making a slight upward connective line, forming next a downward thick slant-stroke, and at the top, towards the right, a small circular connective loop (or dot), with its horizontal connective curve. 

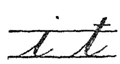
The letter *s* requires a little care of hand and eye. It is begun by making, from the base-line, a slight upward connective stroke, upon that forming a small connective circular loop, as in *r*, and then rounding off with a curve to the right, which

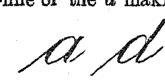
is continued round the base-line to meet the commencing connective slant, on which a dot is made, and a curve is then brought round by the base-line towards the right to form a connecting link with other letters : 

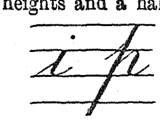
We are now in possession of the following eight additional small letters—viz. *a, c, e, o, s, z,* which may be written in series thus, *o, a, c, e, s, z,* and these, with the five foregoing ones, may yield several exercises, such as the undergiven :—

Exercise.—Write out these words—ocean, oceanic, coarse, course, worse, reverse, scan, scansion, recension, score, sore, more, roar, soar, scarce, environs, eminence, vow, roan, moan, mourn, scorn, rein, rain, main, maim, remain, cream, scream, avenue, revenue, souvenir, convenience, convince, mammon, sermon, immense, immerse, romance, novice, crevice, crevasse, examine, remorse, resources, reminiscences.

Three other letters may now be formed readily by compounding some of the elements previously employed, *e.g. t, d, p.*

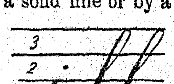
The letter *t* requires only that the main body of *i* should be formed, but that in forming it the main slant-line should be made one-half longer, and that the upper part of that additional length should be crossed by a thin straight horizontal stroke; thus, 

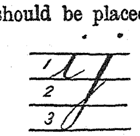
The letter *d* is easily formed by making the letter *a*, but when adding the main slant-line of the *a* making its length equal to that of *t*; thus, 

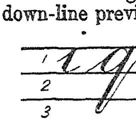
The letter *p* is made by striking the slanting connective of *n*, raising the main slanting line twice the height of the normal unit, *i*, and bringing back the pen down the same line, continuing its course once and a half of the length of *i* below the base-line; then raising the pen in the same main slant-line through two heights and a half, and making the latter part of *n*; thus, 

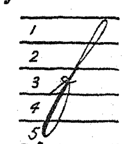
Exercise.—Write out these words—nip, pip, map, tap, partner, pad, padre, pannier, spanned, spurned, dapper, diaper, tattered, tottered, tramped, vamped, cramped, vapid, viper, pain, sprain, stain, domain.

Letter-loops are doublings of long lines upon themselves by curving one line running up or down and bringing another line back alongside of the former one, sometimes nearly parallel with each other, sometimes crossing. Of such loops there are the following varieties :—(1) the upward, *l* loop (which appears in *b, h, k,* and the upper half of *f* and of long *s*); (2) the downward, *j* loop (which is found also in *y, g,* and long *z*); (3) the downward and backward-curved, *q* loop; and (4) the downward and backward-crossing, *f* loop. (See Plate I. line 4.)

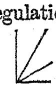
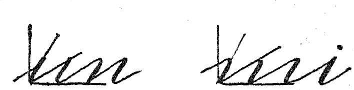
1. To form the *l* loop we place the pen on the base-line of the writing and make an upward-sloping, slightly-curved, light line, rising to thrice the height of the letter *i*; this line we turn, with a width-space of half the distance of letter from letter, towards the left, and after forming a compressed oval make a downward heavy stroke, crossing the previous upward slope at the height of the *i*, and reaching the base-line either as a solid line or by a natural turn, as in annexed figure: 

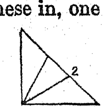
2. To form the *j* loop we place the pen the height of *i* above the base-line and draw a downward-sloped heavy line thrice the length of *i*—one above the base-line and two below—then make, by a compressed oval turning, towards the left, about a half-space in width, and bring the up-stroke slantingly to cut the down-sloped one at the base-line; after which, to make a *j*, a dot should be placed at the length of an *i* above the latter: 

3. To form the *q* loop, after making the *o* oval for the head, we make the downward-sloped line, as in the *j* loop, but on reaching one and a half *i* length below the base-line turn the oval curve towards the right, and bring a light up-stroke parallel to the down-line previously formed, till it touches the base-line: 

4. To form the lower *f* loop, follow the directions given for the *q* loop, but on forming the parallel up-stroke incline towards the left, join, and cross the body of the letter at a half-length of *i* above the base-line: 

We are now able to set before our eyes the letters of the entire alphabet arranged somewhat in the order of their progress from simplicity to complexity of form—thus, *iunmxvwroacestzdpljbhyqgfk*—as distinguished from their alphabetical order, *abcdefghijklmnopqrstuvwxyz*.

We have hitherto been engaged in describing the method of forming the several small letters in the simplest progressive order. But as we can only take up for consideration one matter at a time, we have not spoken yet of a most important element in writing—the slope. A good practical guide for the regulation of the slope in writing is to make a right angle, thus  and to mark it off into three equal sub-spaces, taking the lowest sub-space as the regulator of the connective slant-stroke; let the second space-line regulate the main slant-lines, inclining, if anything, slightly above each division into spaces, 

The pleasantness of writing to the eye, as well as the easiness of its production by the hand, depends very greatly upon the niceness, regularity, and proportion of the slope, which ought always to be the same in each piece of writing. A little latitude may be taken to suit individual tastes; but the above-given guide, which can be simply made by taking a card, and at such a distance as will give a slanting line of 3 inches dotting off lines from the points at 1 and 2 inches to the corner, and then folding these in, one upon the other, the lines of slope will be given : 

In our Plate—Penmanship, small letters—we have endeavoured to present, at one view, a series of examples in elementary writing at once simple and systematic. The ruling is arranged in five spaces, that numbered 1 being the line upon which the body of the writing is inscribed, while those above and below, numbered 2 and 3 respectively, indicate and regulate the height to which the long up-strokes should be taken, and the distance to which the down-stroke letters should be carried. There has been placed in the left-hand corner an arc of a circle, showing the manner in which the slope of the letters may be arranged. On this the main slant slope and the connective slope are marked as having respectively the angular inclinations 52 and 32 degrees. In conformity with these measurements the connective slope-line 1 is formed, the main slant-slope 2 is made, and in 3 these two are exhibited in one com-

bination, while in 4 they appear in a second mode; and in 5 these two combinations are shown producing a new form. These combinations are seen in the second set of special lines entering into and forming the letters *i*, *u*, *n*, *m*, and *x*. Reverting to the uppermost line again, there are exhibited several curved connectives, which enter into the formation of other letters—one which forms part of *v*, *w*, and *r*; a second required in *k* and *z*, a third in *c*, and a fourth in *s*. The third line exhibits oval and semi-oval letters—viz. *o* and *a*, the latter made by combining *o* with slant-line 4 in the first line; *c* a dotted half oval, and *e* a connective slope and a half oval. Combination 5, with a slight curvature inwards and the circular connective attached, forms *v*, and *w* is a compound of *u* and *v*. The letter *t* is an upward extension of combination 4 and crossed; *d* is compounded of *o* and an upwardly-extended uncrossed *t*. The first element in *p* is a connective up-stroke; the second, three and a fourth sizes of form 2; and the third, combination 5. The letter *r* is formed by the circular connective and combination 4. It can also be produced by attaching the circular connective to the right of combination 3. We have in *s*, a connective slope, a circular connective, and a half oval. Line four exhibits the simple long-looped letters. The first of these, *j*, is a very simple form, which reappears in *y*, *g*, the lower part of long *s* and *z*. The *l* is also easy and appears in *h*, *b*, *k*, the upper half of *f* and of the long *s*. The letters *q* and *f* exhibit the line reversed, and *z* is formed by the junction of two circular connectives on the upper line of space one, the element 2, a circular connective on the base-line, and a loop of the *j* sort. Such, under a simple analysis, are the various elements requisite for small handwriting. Taken as exercises the specimens in the Plate will be found to afford ample elementary practice in pencraft.

At present we cannot do more than advise the most careful attention to exactness of form, evenness of size of letter, proportionateness of parts, regularity of slope in all letters, carefulness in joining each letter to its neighbour, and scrupulous cleanliness of writing material—instructions for all which will be supplied hereafter gradually and specifically.

The following directions for self-examinative criticism will, if followed strictly, be found, throughout the whole course of the exercises given and during all special practice, productive of good results:—

1. Write out, with care and attention, copies, one by one, of the examples set.

2. Take each of these examples after they have been purposely written out, and mark the following faults, if any of them occurs, in the example before you, with, for brevity's sake, the numbers here given when indicating the several items.

(1) The down-strokes are *rough* instead of being *smooth* and *even* in the edges.

(2) The down-strokes are *thin* instead of being of a *proper* and *regulated thickness*.

(3) The up-strokes are *coarse* instead of being *fine*.

(4) The up-strokes are *uneven* or *patchy* instead of being *even* and *uniformly regular*.

(5) The strokes are *crooked* or *curved* instead of being *straight*.

(6) The strokes are *unequal in thickness* one to another instead of being *equal*.

(7) The hair-strokes are *disjoined* instead of being *written with the hand unlifted*.

(8) The turns are *clumsy* instead of *graceful*.

(9) The turns are *pointed* instead of *oval*.

(10) The turns are *round* instead of *oval*.

(11) The turns are *unequal* instead of *equal in distance*.

(12) The turns are *unequal* instead of being *uniform in size*.

(13) The turns are *disconnected* instead of being *completely joined*.

(14) The distances are *unequal* instead of being *uniform*.

(15) The ends of the letters are not *square*, as they should be, but *pointed* (or obtuse).

(16) The letters are *too much* (or too little) *sloped*.

(17) The ruled lines (or size-space) have not been sufficiently attended to.

(18) The letters *o*, *a*, *c*, *b*, *d*, *g*, *q* are *flat* or *circular* instead of *oval*.

(19) The letters *t*, *l*, *h*, *b*, *d*, *p*, *g*, *q*, *y* are too low or too high instead of conforming with their co-mates in their formation.

(20) The irregular letters, *r*, *s*, *x*, *k*, are *awkwardly* instead of *gracefully* made.

(21) Any fault, mistake, slip, blot, blotch, ill-joining, or unsightliness ought also to be noted for avoidance, correction, and improvement.

Correct such of the faults as have been made in each of the examples in a fresh copy, and repeat the examination and correction till the whole is satisfactory. If this course is pursued honestly and unflatteringly in examination, carefully and thoroughly in marking, painstakingly and earnestly in correction, difficulties will vanish and faults will disappear. The exercises produced will present correct, precise, and elegant pictures of each letter, and by the continuance of gradual, well-guided exertions, the muscles of the hand and arm will grow insensibly more and more attentive to the influence of the eye, and more submissive to the regulative power of the mind. Effort will be exchanged for habit, and habit will become what it ought to be, a second nature. Beautiful and accurate forms will proceed from the pen-point, and a distinct personal style of writing will become a possession, a utility, and a pleasure.

Write slowly, carefully, at first; form each letter, not only in itself, but in relation to every other, neatly and correctly; be faithfully earnest in doing all you try well. When you have acquired absolute mastery of the pen for the correct reproduction of each letter singly and all combined in any order with the example before you, proceed to writing the same copies from memory alone, testing thus the accuracy of your eye and the deftness of your hand; and formally correct as before, until accuracy and elegance are attained.

After this, endeavours for the attainment of speed may be made. This may be best done by writing short words repeatedly as rapidly as you can consistently with the attention due to the making of each letter distinctly and the whole elegant; then increase gradually the size of the words employed. When the ease of familiarity has been attained in words, take short sentences and extend them as practice supplies capacity. It is, of course, advisable to adopt for this purpose such sentences as are so clearly and distinctly in possession of the memory that no effort of recollection is required, but that all thought may be absorbed in the execution of the writing.

LOGIC.—CHAPTER I.

THE SCIENCE OF REASONING—ITS NATURE AND PURPOSE.

All life is governed by law; law is thus the regulative principle of all existence. To know the laws which link things into systems is to have a scientific hold of facts. A chain of truths, consisting of a series of carefully interlocked reasons and facts, constitutes a science. Systematic thinking brings together in order all the facts which experience presents to the mind, and by showing the principles which work within them, represents them, in thought, as science. Science is experience explained; logic is the science of thought; thought is the activity of the mind exerted for the discovery of truth; truth is that which can be trusted in—the precise reproduction in thought of all that reality presents and implies. The highest and noblest efforts of man have been made for the ascertaining and the maintaining of truth. We call this realizing in the mind of a correct knowledge of things, the substantiation of a truth. Experience is characterized by changeableness; but we feel that under all change there stands the principle of its being, and through all variableness there operates the law of its phenomena. Science is experience seen as a system, having a unity at once in outward reality and in inward reflection. Logic constructs science; hence it is called "the science of sciences," the science of the laws of the operations of thought.

We exist surrounded by experience. This experience influences and affects us as sensation. Sensation is the entire

series of impressions made upon man's mind by the universe which lies around him. Consciousness is man's mental capacity stirred into perceptive activity by the touch of experience, through sensation. To be conscious is to know that we have been brought into relation with a region of encompassing phenomena, from which we feel our difference, and by which our sense of selfhood or separate individuality is excited and made manifest to us. The hitherto unstirred possibilities which are stored within us, of sensation, intuition, emotion, reasoning, and volition, are now all quickened and become possessed of vitalized power. Nature is made luminous to mind; sensation has transferred experience into conscious perception.

At first, life manifests itself by instinct and impulse; it wants definiteness of aim and determination of action. Our predispositions are not reflective, and we are unable either to represent consciously and continuously to ourselves the outward forms of things, or to hold distinctly in or before ourselves the intents (or the desires, rather than the designs) of our minds. By and by we take together as concepts things bringing to or originating in us similar experiences, and noticing the sense of sameness which runs through them all, we gather them up into perceptions, recognize them as things or acts, and give them names. Thus we mark, note, separate, and define the elements of our experience into perceptions, and gradually acquire progressive mastery over all the phenomena which nature presents. Names are expressions of that which experience has presented as impressions. Thus perception acquires significance, and this significance is registered in a sign, a symbol, a name. Language represents perceptions.

Perceptions pass into the mind as distinct possessions of thought by the collecting of like impressions and marking them off from unlike ones. Thus we become conscious of similars and dissimilars not only in quantity, but in quality; not only in simultaneous, but in successive impressibility; not only as constant, but as inconstant in their appearance to the mind; and not only as existent, but persistent in experience. As to quantity, they may differ in sum or arrangement; and as to quality, they may possess equality or inequality of impressive power. In this way the ideas of identity and of exclusion, of explicit and implicit relations, and many other characteristics of perceptions and their signs (names), acquire fixed abiding in the consciousness, and from the very names of things we can deduce many immediate results which aid our thought in dealing with words and things. Names of things, when expressive of the actual perceptions in consequence of which they have been given, often enable us at once to perceive the coincidence or incoincidence, agreement or disagreement, of idea with idea. Things, for instance, cannot at the same time be like and unlike, simultaneous and successive, and these characteristics mutually exclude each other in the particular relation in which they are considered. Such ideas are said to be opposed or contradictory—that is, incompatible.

Classification becomes possible when we know properly, perceive clearly, and can appreciate fully the implications of the qualities of things. A class consists of such things as are distinguishable from all others by some one common characteristic (or more) having sufficient obviousness, permanence, and importance, and by the possession of which they are all able to be thought of as related to one another. When such a characteristic (or characteristics) can be found a class may be legitimately formed, and all things marked by the possession of the relating characteristics are, so far forth, capable of being reckoned, in that regard, as members of that class and constituents of that classification.

By thus drawing distinct boundary lines round the area of thought within which any specific series of objects may be included, the investigator is able to direct entire and undistracted observation to the contents and qualities of each thing which claims admission to the class, at once and with certainty. The identical element (or elements) of the relation being determined, the mind is released from considering irrelevant peculiarities, and thus economy and exactness of investigation are secured. Science requires precision of thought and of language. The distinct marking off of one idea from another by definition, and the arrangement of ideas and the things which they represent into classes, very considerably tend to accuracy of thought and the ease with which the mind can deal with ideas. Such careful and precise demarcations conduce to the possibility of accurate habits of thinking, and by keeping the ideas in the mind separate from one another, by distinct definition, the cultivation of the understanding is greatly aided; because thereby the persistent selfsameness of the ideas, perceptions, and sensations brought together into unity as a class is to a large extent secured, and reasoning regarding them is made satisfactory.

Being is conscious existence; *thinking* is the consciousness of other existences; consciousness is the proof of personal and individual existence in the midst of the phenomena of the outer world of experience. The mental activity of thinking is reflective; it represents the world as external, and it supplies itself with signs of this external—extra-mental and experimental—world, in the names it employs, and in the language which forms the medium of expressing its thoughts. In consequence of this mirror-like faculty of mind words have become the counters of thought, and many have been led to regard logic as merely the regulator of language as the instrument of thinking. Whately, for instance, held that "logic is concerned with language, and with language only;" but then, clear thinker as he was, he went on to use language (1) as the sign of thought in the mind, and therefore the representative of thought (*a*) in itself, (*b*) to ourselves, and (*c*) to others; and (2) as the sign in the mind of facts, and therefore again the representative of experience (*a*) as felt by us, (*b*) as conventionally understood by others, and (*c*) outwardly existing—so far as we could know it. In this way things, words, and thoughts were the counterparts of each other, and each *term* was, in point of fact, *thought* on the one (the mental) side, and *experience* on the other (the experimental) side. Language was manipulated as the sign of both, and what was true of the one was accepted as true of the other. The ambassador was, for his purpose, the vicarious representative of both dominions—mind and matter. Hamilton, again, held that language was a cumbrous, imitative substitute for thought, through and with which we must work as best we may—a paper currency, as it were, neither truly representative of the reality of property nor of the coinage which conventionally, under the name of capital, takes its place representatively. His logic was not a mere grammar of intellectual philosophy, but a mental science—the science of the laws of thought, as thought—(1) formal, (2) constructive, and (3) critical: *formal*, as having nothing to do with the objects of knowledge, but only with the operations of the mind in thinking; *constructive*, as building up the entire fabric of logical science out of the three formal laws of thought—(1) identity, (2) self-consistency, and (3) exclusion; *critical*, as insisting on an introspective review of all the powers of mind engaged in thought, of all the operations involved in thought, and of all the products possible to thought, so that all that is implicitly contained in the language which represents thought may be explicitly stated in the exposition of the laws of thought. Mill, again, takes logic to be the theory of evidence, a science of the operations of the understanding. He gathers his theory into the correct performance of the three simple operations, (1) of naming, (2) of stating what is thought in propositions, and (3) of conjoining these so as to yield inferences and take their place as evidence. De Morgan looked on logic as a series of equations between (1) ideas and words, (2) propositions and facts, (3) inferences and realities. Boole constructed an algebra of inference, and Stanley Jevons carried still further the idea of making logic a sub-branch of mathematics. Some foreign thinkers have propounded other views. Kant takes under his review the origin, extent, and limits of human knowledge, and defines logic as the science of the necessary laws of thought. Hegel holds that *thought* is the real counterpart of *being*, and that, in being, all thought is implicitly contained as in a germ. This only requires to be developed and its fruitage becomes philosophy, science, history, &c., having for its flowerage art, poetry, and pleasurable emotion.

In all these systems, as well as in those of Plato and

Aristotle, who held, in the early days of speculative thought, the same relations to each other as the idealists and the realists of the middle ages, the necessity of care in the forming of conceptions, of giving names, and of defining terms is acknowledged, insisted on, and provided for. The relations between thought and language are felt indeed to be embarrassing, and the need of seeing that words and ideas really correspond is kept clearly before the mind. Whatever definition of logic we adopt must be interpreted in accordance with a right relation between language and thought. Thought must be precisely represented, or at least indicated, and if in any case the substitution of similars in language is resorted to the exact equivalence of the similars must be carefully attended to.

"Words may be," as Bishop Berkeley says, "arbitrary, outward, sensible forms, having no resemblance to, or necessary connection with, the things for which they stand or which they suggest;" there may be no "pre-established harmony" between language, as the symbol of thought, and the things thought of; but logic must, if it would teach men to think rightly, insist on the proper and concise expression of each thought in suitable words. This will only be properly done when we distinctly recognize (1) that thought is the product of perception, (2) that perceptions are denoted or symbolized in and to the mind by words, so that (3) words are doubly related, (*a*) to thoughts and (*b*) to things, as representatives. If, therefore, our perceptions have been derived from sensations carefully and discriminatingly made, they will be free from indistinctness in themselves and confusion with each other; they will be clear, adequate, and definite, and then they must be uniformly employed in the same sense. For if they are not thus used in an expressly similar signification they are then being employed, not as the sign of one distinct and unique idea, but of two; and these two even are not clearly marked off one from another. This distinction is pressed upon us by the logical rule that in the use of language our words should be univocal, not equivocal, *i.e.* possessed of one determinate sense, not of a loose and indeterminate one.

A clear reasoner, an adroit arguer, or an accurate thinker is not necessarily a logician. If, with spontaneous power and uneducated or untrained skill, a man's mind works steadily and unconsciously towards the attainment of truth with an unmistaken thoroughness of trustworthy thought, he may well regard himself as endowed with a pricelessly precious gift. This is an endowment, not an acquisition. Logic engages in observant watchfulness of the manner in which the best thinkers reflect; in ascertaining the processes through which thought passes, in such minds, in its course from an apprehension of things to the knowledge of the principles of their existence and the laws of their operations. Logic is a scientific system, not a craft. It is cultured wisdom. Thought is the material whose laws logic examines, explains, sets forth in systematic order, and demands obedience to. Language constitutes the body of signs in which thought is usually expressed. But language is a ready, practical handmaid to life. It ought, with fulness, clearness, and precision, to express all that is in the mind when thinking. This, however, it seldom does. It is in haste, and its users are in a hurry. It omits, it hints, it suggests, it employs ellipses and idioms. Logic claims as a pre-requisite to the use of language in its service, that it shall be a simple, unmistakable, clear, and precise exponent of what is thought; and hence it deals with language as thought's agent and medium, its symbol and sign, and issues all its missives with due ceremonial attestation, so that it may be unhesitatingly accredited.

All thought has its origin in conception, *i.e.* in the forming of ideas. Conceptions pass through the ordeal of logical legitimation, in order that they may be, with confidence, accepted and employed as the contents of thought, and may be looked on as the certified and signatured copies of the mind's experience; they are then called *perceptions* or *ideas*. The attribute or attributes, in the possession of which a plurality of objects submitted to the mind in experience agree, are found to be coincident and thoroughgoingly one, are marked and noted as such, and so become elements of knowledge and receive names. Names denote perceptions or ideas, and connote or tacitly imply (1) an original cause of perception in thought, and (2) an experience either of external impression or of mental consciousness. Logic regulates the formation of perceptions, governs the naming of them, classifies, generalizes, and defines them, and insists on their univocal and unequivocal use. The old logicians called this Simple Apprehension. It is perhaps better named, in relation to the product of the operation, Perceptivity, or the capacity of forming perceptions, whether derived from mental or extra-mental sources, from experience or reflection.

Perceptions may be of several sorts, such as (1) *individual*, represented by a proper name or its equivalent; (2) *specific*, indicating a class of greater or less numerical extent, and with a certain number of distinguishing attributes; (3) *generic*, including several classes and comprehending them in a higher unity of idea.

Perceptions as the representatives of experience, sensational or intuitional, are necessarily able to be thought about as holding certain relations towards each other, and may be considered, by the mind, as either (1) really or (2) possibly connected with each other in these relations. The act of the mind by which ideas or perceptions are regarded as related to each other, is called an act of *judgment;* the sentence in which a judgment is expressed, is named a *proposition*, or a setting forth of the decision of the mind on the relational connection of the perceptions brought under its consideration; and the words employed to denote the perceptions, examined and made the subject of a decision or an act of thought, are known as *terms.* Let—to take a plain illustration—the idea of Milton or Blackmore be made the subject of conscious intentional comparison with the idea suggested by the words *great epic poet;* and let the judgment come to be expressed in regard to each. The judgment would (probably) emerge in the following propositions:—(1) Milton is a great epic poet; (2) Blackmore is not a great epic poet; and the names of the representatives of the perceptions "Milton" and "great epic poet," and "Blackmore" and "great epic poet," would be the terms respectively in each of the propositions. The words *is* and *is not* are most commonly called the *copula;* though some writers restrict that name to that part of the verb *to be* which joins two terms together, and regard *not* as a portion of one of the terms. This need not now be discussed, as the matter will come under consideration in our systematic exposition. The congruence or compatibility (*i.e.* agreement) of one idea with another is expressed in an affirmative proposition, and incongruence or incompatibility (*i.e.* non-agreement) in a negative one.

The relation of propositions to one another is provided for by the *syllogism.* As Sir William Hamilton said, "The most complex web of thought may be reduced to simple syllogisms; and, when this is done, their truth or falsehood, at least in a logical relation, flashes at once into view." A simple syllogism is one in which two judgments which are different, yet have a common part, are so brought together as to show that a third and different judgment may be deduced from them. The common element is called the middle part, the two judgments premises, and the third the conclusion. According to the relation which the middle term holds to the other terms in the respective premises, syllogisms are arranged into figures or forms of reasoning, modes of formal thought. The "Organon" of Aristotle is an explanation of syllogistic logic as an instrument in correct thinking.

Correct thinking may be exercised upon either (1) the discovery of truth, or (2) the imparting or exposition of truth. In endeavouring to render the processes of syllogistic reasoning serviceable for the purposes of the scientific investigator the logician distinguishes between analytic and synthetic reasoning, and inductive and deductive thought, and shows how each is to be pursued in order that the results of thoroughgoing thought may manifest themselves as science —a series of systematically reasoned truths explanatory of experience, and capable of being perceived by the mind as a body of clearly arranged and accurately co-ordinated principles, forming one organic whole, however great their variety.

Evidence is that which is seen arising out of experience during the course of the investigations of the intellect regard-

ing any subject. It may be immediate or mediate in its manifestation; it may be intuitive or experimental in its source; it may be original, underived, and unborrowed, or it may be derivative, borrowed, and even compulsorily attained; but it must appear clearly and plainly before the investigative faculty, in order that it may be held in the mind as ascertainable fact capable of being used as proof in relation to the matters regarding which investigation is being made.

Inference is the form of thought by which we carry our investigations through a series of reasonings or syllogistic processes; inference widens and extends the knowledge gained by experience, by enabling us to add link after link to the series of truths which a knowledge of facts furnishes, and it constitutes a most important portion of the process by which truth, in a scientific form, is discovered and utilized. Inference demands that observations be exact, repeated, and numerous. By it science changes sight into insight. There is a scientific and an unscientific method of looking at things. There must be some specialities by which the former is distinguished from the latter, and which constitute the superiority of the former. What these are, logic investigates, and it endeavours to explain the share taken by each faculty of the mind in the structure of science; it exercises and trains, educates and cultures the formative and organizing capacities of the mind, and shows the means whereby the appearances and suggestions of experience may be best collected and compacted into intellectual representations, ideas, or perceptions, and most clearly brought under the power of mental apprehension; it determines, defines, and specializes experience into congruent, manageable groups, whose qualities and attributes are possessed of a uniformity of action on the mind, and make themselves patently observable as the appropriate characteristics of these classes of things.

Logic is experience explained with a mental aim; science is experience explained with an experimental one. Logic need not, unless it chooses, examine whether the conceptions it has formed of things or powers are real or imaginary; science must know this unmistakably. Logic can supply science with instructions concerning the verification of experience, and so enable it not only to know and distinguish the imaginary and the real, but to contribute assurance of the same to all investigators. Science asks, What is the reason why any specific experience manifests or possesses certain peculiar attributes? Logic suggests the forms of test and regulates the processes of inquiry, by which the queries of science may be (and are) satisfactorily answered; but it takes care to suggest that a prior question ought to have been (and must be) put—Is it a fact that a given experience is in reality the possessor (even though it may be the manifestor) of a particular attribute?—and it sets science to clear up that point by cautious reinvestigation. The demonstration of this, as a fact, makes that a proper topic for inquiry and speculative research, and logic thereafter sets itself to work to define the characteristics of the attribute inquired into, and of the objects of experience by which it is manifested. Observation is regarded by logic as mere cognizance of phenomena, until its results have been re-examined under selected conditions, which are intended to distinguish between (1) antecedents, (2) concomitants, (3) realities. Logic is therefore the provider of a method of investigation—method being used in accordance with its Grecian origin, which, as Coleridge says, literally means a *way* or *path of transit*. Hence the first idea of method is a *progressive transition* from one step in any course to another. This course of progress from the ascertained facts of experience to substantiated principles is inference, that sort of reasoning which transforms sensation into science.

In the class of impressions resulting from experience and arising within ourselves we require some means of marking off with distinctness perception from perception. But nothing in experience makes explicit at once or at first sight all that is actually contained in it. Guarded observation and careful reflection bring into notice much that is non-apparent. Out of the (partially) known we elicit what was before unknown. The objects we see around us manifest themselves by their qualities; but the qualities that are most obvious and self-revealing are not always those in which the chief characteristics of things reside, and science wishes to learn the secrets of nature. Logic teaches it to seek, through and beyond the sensible early impressions things make, their inner and less known but more important qualities and attributes, and thus induces the culture of that brighter seeing which transcends mere sight, and reveals the principles through the attributes of things. Man's faculty for forming ideas, and becoming informed through perceptions, is the initiative power in which science has its origin. Here we begin to seek the earliest manifestations of the necessary laws of thought according to which the illimitable series of demonstrable truths that constitute science are progressively ascertained. When every perception is precisely coincident and commensurate with the total of what is experienced, and when only the essential, entirely dissociated from the accidental, is included in our ideal of objects, all our perceptions will be adequate and appropriate. When our terms express with absolute accuracy not only what we think, but what we experience, and names are used with intransferable fitness to those objects alone which are characterized by exactly the same attributes, possessed and manifested in the same proportions and with the same powers, the propositions in which we state the results of our investigations will be valid and distinct statements of inclusion or exclusion, of congruity or incongruity, of relatedness or irrelation; and hence all syllogizing, reasoning, placing of propositions in inferential relation to each, and consequently all conclusions legitimately drawn from properly arranged premises, will be trustworthy and demonstrably true. Knowledge of fact and knowledge of reason will be brought into a harmonious unity by an indissoluble succession of minute steps. Let us show how this becomes the case:—

The planets do not sparkle (or scintillate)—as observation proves.

Such heavenly bodies as do not sparkle are nearer the earth than those which do—as well-planned experiments show.

The planets are therefore near to the earth.

The planets are near to the earth.

Such heavenly bodies as are near the earth do not sparkle.

Therefore the planets do not sparkle.

Many other instances might be quoted, but this may suffice to show that thought and fact reciprocally concur in transforming experience into science, and making science again give experience a higher truth and greater attractiveness.

The logical principles on which these instances are shown to be valid in reasoning, of course, require exposition, and this will be provided in the sequel of this series.

The facts of sensible experience do not constitute science, that is, reasoned truth as distinguished from classified fact. Science explains facts, because it searches into and discovers the reason or principle of the causes of things. Every science has its own special department of fact to explain. The discovery of the laws of the phenomena of its facts is an intellectual operation, a process of reasoning. The discovery of the laws of reasoning, and the exposition of the forms and phenomena of thought, are the functions of logic. Logic is the science of reasoning as a mental statement of principles. It is the art of reasoning when it is brought into use as a practical exercise of the principles of thought in actual thinking.

Logic is thus the science of the means by which all other sciences are perfected. It supplies, in its principles, an *Organon* or instrument for constructing a knowledge of facts into a reasoned and systematic representation of the truth of things as science. It interprets experience; it regulates the experiments which test or attest the reality of things. It explains the modes of conducting speculation and investigation. Logic has an important and valuable part to perform in self-culture; it trains the mind to introspective watchfulness of its operations. It exercises dominion over the observations by which our experiences are transformed into perceptions, and criticises the accuracy and appropriateness of the names we use and the manner in which we employ them. It explains the correlations of words as expressive of thought, and acts as a director of intelligence in the pathway of inference and reasoning; it plans the means by which study may best

attain its object, and promotes in every operation of the mind discriminating care in the processes either of pursuing or receiving knowledge. From the lowliest exercise of sensation to the most magnificent flights of genius in physics or philosophy, science or poetry—from the simplest lessons of the school to the most glorious studies in nature or history—logic is a help, a guide, an instructress, and an inspirer.

CHEMISTRY.—CHAPTER I.

INTRODUCTORY—CHEMICAL AFFINITY—DECOMPOSITION—COMBINATION—CHEMICAL EQUIVALENTS—CHEMICAL ACTION.

THE objects which surround us on all sides, and which we can see, handle, or weigh, constitute what is termed *matter;* and *chemistry* is that department of general physics which treats of the nature and properties of matter under its various forms and combinations, and establishes the laws which concern the intimate constitution of bodies, not as respects their structure or the manner in which their parts are put together, but as regards their materials or the ingredients of which those parts are composed. All matter is supposed to be constituted of very minute particles termed *molecules*, and these again to be composed of still smaller particles termed *atoms*, which are absolutely indivisible. [See NATURAL PHILOSOPHY.] Many common chemical experiments afford illustrations of the inconceivable minuteness of the ultimate atoms of matter. If a grain of copper be dissolved in nitric acid (*aqua fortis*), and added to a quart of water, a solution will be obtained which is sensibly coloured blue. The copper therefore is diffused throughout the whole, and is readily detected in the hundredth part of a grain of the solution. Now, the quart of water weighs 14,500 grains; consequently a particle of the colouring matter is less than the 1,450,000th part of a grain. But this is not all. Whatever may be the size or weight of the ultimate atoms of matter, every atom of the colouring matter of this solution is made up of two atoms, one of copper and one of nitric acid; and further, every atom of the nitric acid is composed of six atoms of matter. We might therefore, perhaps, multiply the 1,450,000 by 7, for the weight of the atom of our copper. Let the hundredth part of a grain of the solution be placed on a clean iron surface, as the blade of a penknife; the copper will adhere to it in its metallic state, and it will at once be seen that the particle of liquid, instead of containing only one atom of the copper, as was assumed, contains many—more, indeed, than the experimenter will find means to determine.

The three great forces of nature, *affinity*, *cohesion*, and *gravity*, which respectively bind together the atoms into molecules, the molecules into bodies, and unite the bodies into masses [see NATURAL PHILOSOPHY] belong more especially to the physical properties of matter. *Chemical affinity* unites particles or atoms of different kinds of matter together, forming compound atoms, aggregations of which are termed compound bodies; it is a modification of the attractive force which presides over the composition of bodies, and produces all chemical varieties. The nature of chemical affinity will be understood by an illustration of its action. If a piece of lead be melted, and a bit of tin be gently laid on its surface, it floats there as a cork would on water, because tin is lighter than lead. In a short time the tin will melt with the heat; and being lighter, would naturally be expected to constitute the upper stratum when the two metals have grown solid by cooling. It happens, however, otherwise; for neither the lead nor the tin retain their respective situations; both metals are perfectly blended; and a particle cut from the lump, whether top or bottom, will be found to be composed of both tin and lead. The attraction which has so effectually blended the particles of the metals (forming the compound termed *pewter*) has operated in opposition to gravity, and differently from cohesion; it is an instance of affinity.

Affinity does not manifest itself in all cases under the same circumstances. Thus, if a rod of iron be immersed in mercury (quicksilver), no effect is produced; the rod on being taken from the mercury exhibits no appearance of having been immersed. But if a rod of gold be similarly immersed, and taken out, it will be found remarkably changed: it will be white, and covered with a coating of mercury which no mechanical force can remove; and if left long enough in the mercury, it will be soft and brittle. It will be penetrated by the mercury, and any portion scraped from its surface will contain both gold and mercury.

The same phenomenon of dislike and preference, or affinity, is manifested between liquids. Thus, oil and spirit of wine are both lighter than water. If we cautiously pour into two glasses, each containing some water, a quantity of oil and a quantity of spirit of wine respectively, the oil will continue to float on the surface of the water for any length of time, it having no affinity for that liquid; but the spirit of wine, on the other hand, will speedily descend to the bottom, and be equally diffused through all parts in consequence of the affinity exerted between it and the water.

Chemical attraction is exerted between the atomic particles of bodies in every different degree from zero upwards. That is, of three bodies, A, B, and C, although A may have affinity for both B and C, it rarely happens that that affinity is manifested in equal intensity for both, but in different degrees of force. Take, as an instance, three substances in common use—soda, magnesia, and sulphuric acid (oil of vitriol). The sulphuric acid has an affinity for both soda and magnesia, and will combine with either of them. But suppose that these three substances are mixed together, notwithstanding that the acid has an affinity for both soda and magnesia, one only of these affinities is obeyed; the sulphuric acid combines with the soda, and the magnesia remains unaffected, when the quantity of the acid is within certain limits. The knowledge of this fact enables what is termed *decomposition* to be carried out. When some Epsom salt (sulphuric acid and magnesia in combination) is dissolved in water, a clear and transparent solution is obtained; but the moment a little solution of soda is poured in, the sulphuric acid of the salt will separate from the magnesia and combine with the soda, and the magnesia, which was formerly invisible and in a state of solution, will now appear, and will after a time settle to the bottom in the form of a white powder. The salt in this process is said to be decomposed, and the process itself is a case of decomposition; and further, the falling down of the magnesia is called precipitation, and itself a precipitate.

Most of the great changes which are constantly taking place in nature are instances of decomposition. It is by decomposition that the solid rock becomes covered with fertile soil; it is by the same process that the soil throws up its verdant clothing, that growing plants are converted into animals by assimilation, that animals at length fall into decay and return to their original state—in fine, it is by decomposition that the great natural processes of renovation and decay are kept in a state of perpetual circulation.

When a substance cannot be decomposed into two or more elements it is termed a *simple substance;* but when it is made up of two or more elements it is termed a *compound*, and the elements composing it are stated to be in *chemical combination*. Copper is a simple element, for all the particles of which it is composed possess exactly the same properties; but brass is shown to be composed of copper and zinc, and is therefore a compound substance. Similarly, iron is a simple substance; but steel and cast-iron are compounds, for they are resolvable into iron and carbon (charcoal). Chemical combination, moreover, is essentially different from mechanical mixture. This merely implies the mixture of bodies, without attraction of the parts by affinity. If water be added to water, or sand to sand, the effect is an increase of quantity, but no other change is effected; the mutual action of the particles is entirely mechanical. But where chemical action does take place there is a real change, and the resulting compound differs more or less completely, in its leading characters, from any of its component parts. For instance, culinary salt, which is not only harmless, but wholesome, is composed of two formidable ingredients, either of which, taken into the stomach, proves fatal to life; one of these is a metal, and the other an air or gas—the former called *sodium*, and the latter *chlorine*. Similarly, the well-known medicine, Glauber's salt, is composed of two caustic poisons; the one oil of vitriol (sulphuric acid), and the other

soda. The air which we breathe, and which is indispensable to life, is a mechanical mixture of the same ingredients, which, when chemically united, form that most violent and destructive liquid called nitric acid (*aqua fortis*). This powerful acid, by being made to act upon sugar, the sweetest of all things, produces a substance intensely bitter to the taste.

Charcoal is, of all known substances, the most difficult to convert into vapour: it is also a very solid substance; and diamond, which is nothing but crystallized charcoal, is one of the hardest bodies in nature. Sulphur, in the solid state, is also a hard substance, and to hold it in vapour requires a high temperature. But when these two substances—charcoal or carbon, and sulphur—are made to combine chemically, so as to form the substance called bisulphide of carbon, their properties are strikingly changed. Instead of the compound being hard, it is a thin liquid, and is not known to freeze or solidify at any degree of cold that can be produced. Instead of the compound being difficult to vapourize, it is, of all liquids, one of the most easily converted into vapour. Charcoal is the blackest substance with which we are acquainted; sulphur is of a lively yellow hue, but the compound is as colourless as water. Charcoal has no smell; the smell of a piece of sulphur is not peculiarly disagreeable; the smell of the compound is about the most disgusting that can be conceived. And, in fact, the compound has not one point of resemblance with its components. These facts sufficiently illustrate the distinction between mechanical mixture and chemical combination, and the changes of properties which follow from the last.

In chemistry the number of admitted elements is sixty-seven, and new ones are continually added as the science advances. The most general law which has yet been discovered in chemistry is, that all the elementary substances in nature are susceptible of entering into combination with each other only in fixed or *definite proportions*, by weight, and not arbitrarily; thus when any two substances are placed together with a view to unite them, if their weights are not in some certain determinate proportion, a complete combination will not take place, but some part of the one or the other substance will remain over and above and uncombined, so that for every atom present of one substance there is exactly one, two, or three, and so forth, of the other. Consequently, if in any compound there are exactly 1000 atoms of one substance, there will be 1000, 2000, or 3000, and so forth, of the other, and not any intermediate number, as 1400, 1800, &c. Thus a certain number of atoms of mercury, weighing 25 grains, combine with another certain number of atoms of sulphur, weighing 2 grains, and form the black compound called sulphide of mercury, and if a little more of either ingredient be added, it lies as a foreign substance, and does not enter into combination; but if just as much sulphur be added as at first (namely, 2 grains), so that there may be two atoms of it instead of one in every particle of the compound, a perfect combination of the whole will take place, forming the well-known substance vermilion. Thus it appears that although the exact number of atoms in a given quantity of any substance is unknown, still as the weight of the whole sulphur is to that of the whole mercury as two to twenty-five, the single atoms must have the same relation, or that the atom of mercury is twelve and a half times as heavy as one atom of sulphur. From considerations of this nature tables are formed, exhibiting the relative weights of the atoms of different substances, and the numbers which express them are called their *atomic weights.* Thus, if the atom of sulphur be taken as 1, that of mercury will be $12\frac{1}{2}$.

The application of heat to a piece of ice will convert it into a liquid—*water;* if the water be still further heated, it will be converted into a vapour—*steam.* Ice and steam are therefore only different forms of the same substance—water; for by cooling the steam it is again converted into water, and the water, by further cooling, may be solidified into ice. The changes here described are physical changes, and belong to the science of physics, which treats of the temporary changes produced by the action of force upon matter. When, however, an intense heat is applied to the steam, it will be found that it undergoes a remarkable and permanent change in its properties: it no longer yields water on cooling, but remains a permanent gas, possessing explosive properties not possessed by the original steam. The steam is, in this instance, said to have undergone a *chemical* change. Chemical action is therefore quite different from physical action, as the changes wrought by it in matter are of a *permanent* instead of a *temporary* nature. Thus, while physics treats of the temporary changes produced in matter by the action of forces, chemistry includes all cases in which permanent change is produced in matter either by the action of physical forces or by the action of the various forms of matter upon each other. It is the province of chemistry to investigate these and similar changes where a single substance is resolved into two or more others, having different properties from it, and from each other; and to inquire into all the circumstances which can influence them, and either determine, modify, or suspend their accomplishment—whether such influence be exercised by heat or cold, by time and rest, by agitation or pressure, or by any of those agents of which a knowledge has been acquired, such as electricity, magnetism, light, heat, &c. Chemistry is intimately connected with most of the arts and manufactures of civilized life. The bleacher, by the application of a process purely chemical, decomposes the colouring matter of the thread and renders it easy to remove. The dyer extracts the colours of many substances by chemical processes, brightens their brilliancy by a multitude of chemical agents, and, by the intervention of others, fixes and renders them permanent in the cloth. The brewer, by a regulation of circumstances, changes the qualities of the fermenting substance, and obtains products suited to his object; and from which the distiller, by a chemical process, can separate the "ardent spirit," in which their principal qualities reside. The soap-maker converts tallow and soda into soap, and the tanner changes hides into leather by purely chemical means. The manufacture of glass and of porcelain, and the fabrication of paper, depend upon chemistry. The metals are extracted from their ores, purified, and formed into instruments for use and for ornament, by chemical aid. In fact, it would be difficult to name an art or a manufacture which does not depend more or less on this science.

CHAPTER II.

ELEMENTARY SUBSTANCES—MOLECULES—AVOGADRO'S LAW—DISTRIBUTION OF THE ELEMENTS—COMPOSITION OF THE EARTH'S CRUST—LAWS IN CONNECTION WITH THE THREE STATES OF MATTER—AVOGADRO'S LAW AND MOLECULES—WAVE-LENGTHS OF LIGHT—MAGNITUDE OF MOLECULES—DEFINITE MASSES OF MATTER—ATOMS DISTINCT FROM MOLECULES—BOYLE'S LAW—VELOCITY OF MOTION OF MOLECULES—TEMPERATURE—LAW OF CHARLES—MOLECULAR STRUCTURE OF LIQUIDS AND SOLIDS—FORM OF LIQUID MASSES IN SPACE—MOLECULAR STRUCTURE OF SOLIDS.

ALL substances in nature are divided into two great classes—*compound* substances, or those which are capable of being split up into two or more distinct materials; and *elements*, or simple substances, which are incapable of being split up or decomposed, and out of which nothing but the original substance can be obtained. For the sake of convenience the elementary bodies have been divided into two classes—the *metals* and the *non-metals.* The metallic elements are such as gold, iron, tin, &c.; the non-metallic, those elements which form gases at the ordinary temperature, such as oxygen, hydrogen, &c., and certain solid elements, as sulphur, charcoal, &c. The number of metals is much larger than that of the non-metals. At present fifty-two metals and fifteen non-metals are known, and these sixty-seven elements constitute the material out of which the science of chemistry is framed. All matter is made up of these elements, either in the uncombined or simple state, or combined together in the form of compounds. Chemistry has for its object the experimental examination of the properties of the elements and their compounds, and the investigation of the laws which regulate their combinations one with another.

ELEMENTARY BODIES.

METALS OF COMMON OCCURRENCE.

	Symbols.	Combining Weights.		Symbols.	Combining Weights.
Aluminium, .	Al	27·3	Magnesium, .	Mg	23·94
Antimony, .	Sb	120·0	Manganese, .	Mn	54·8
Barium, . .	Ba	136·8	Mercury, .	Hg	199·8
Bismuth, . .	Bi	210·0	Nickel, . .	Ni	58·6
Calcium, . .	Ca	39·9	Platinum, .	Pt	194·5
Chromium, .	Cr	52·4	Potassium, .	K	39·04
Cobalt, . .	Co	58·6	Silver, . .	Ag	107·66
Copper, . .	Cu	63·0	Sodium, . .	Na	22·99
Gold, . . .	Au	196·2	Strontium, .	Sr	87·2
Iron, . . .	Fe	55·9	Tin, . . .	Sn	117·8
Lead, . . .	Pb	206·4	Zinc, . . .	Zn	64·9

METALS OF RARE OCCURRENCE.

	Symbols	Combining Weights.		Symbols.	Combining Weights.
Beryllium, .	Be	9·0	Rhodium, .	Rh	104·1
Cadmium, .	Cd	111·6	Rubidium, .	Rb	85·2
Cæsium, . .	Cs	133·0	Ruthenium, .	Ru	103·5
Cerium, . .	Ce	141·2	Scandium	Sc	44·0
Didymium, .	D	147·0	Tantalum .	Ta	182·0
Erbium, . .	E	166·0	Terbium, .	Tb	148·5
Gallium, . .	G	69·9	Thallium, .	Tl	203·6
Indium, . .	In	113·4	Thorium, .	Th	231·5
Iridium, . .	Ir	192·7	Titanium, .	Ti	48·0
Lanthanum, .	La	139·0	Tungsten, .	W	184·0
Lithium, . .	Li	7·01	Uranium, .	U	240·0
Molybdenum,	Mo	95·6	Vanadium, .	V	51·2
Niobium, . .	Nb	94·0	Ytterbium, .	Yb	173·0
Osmium, . .	Os	198·6	Yttrium, .	Y	89·6
Palladium, .	Pd	106·2	Zirconium, .	Zr	90·0

NON-METALS.

	Symbols.	Combining Weights.		Symbols.	Combining Weights.
Arsenic, . .	As	74·9	Nitrogen, .	N	14·01
Boron, . . .	B	11·0	Oxygen, . .	O	15·96
Bromine, . .	Br	79·75	Phosphorus,	P	30·96
Carbon, . .	C	11·97	Selenium, .	Se	78·0
Chlorine, . .	Cl	35·37	Silicon, . .	Si	28·0
Fluorine, . .	F	19·1	Sulphur, .	S	31·98
Hydrogen, .	H	1·0	Tellurium, .	Te	128·0
Iodine, . .	I	126·53			

In the list of chemical elements given above a number has been placed against the name of each substance, which for the present may be termed its proportional number. Many of the elements are very abundant and widely distributed; thus oxygen is present throughout the air, sea, and solid earth; while others, such as yttrium, erbium, indium, &c., have only been found in such small quantities that their properties have not as yet been satisfactorily examined. The distribution of the elements is irregular; four are found in the atmosphere, thirty have been found in the sea, and the whole of the known elements are found in the solid mass of the globe. The bulk of the solid body of the earth's mass is, however, made up of only eight elements, the rest being found in very small quantities. Thus the composition of the earth's crust, 100 parts by weight, is:—

Oxygen, .	44·0 to 48·7	Calcium, . .	6·6 to 0·9
Silicon, .	22·8 " 36·2	Magnesium, .	2·7 " 0·1
Aluminium,	9·9 " 6·1	Sodium, . .	2·4 " 2·5
Iron, . .	9·9 " 2·4	Potassium, .	1·7 " 3·1

Although the sixty-seven substances enumerated have been termed chemical elements, modern chemistry does not admit that this term should express the meaning that these substances are self-existing essences out of which the universe has been formed. Chemistry, in its true sense, knows no difference between elementary substances and any other class of substances, except the distinction already pointed out. It is quite within reason to assume that other elements exist at present undiscovered. Within the last few years spectrum analysis has been the means of discovering five new elements, and it is quite within the bounds of probability that some of the substances now classed as elementary, as new and more accurate methods of examination are devised, may prove to be compounds. For some time potash and soda were considered as elements, until Sir H. Davy proved them to be compound bodies. It will be necessary before entering into the law of definite proportions in the combinations of the elements one with another, and the theory of atomic weights and principles of chemical notation, to recapitulate shortly some of the laws connected with the three states of matter, solids, liquids, and gases, which are given fully in the physical sections of this work, and to which reference must be made for detailed information. The present summary is given to enable the sequence of chemical formulas to be understood without constant reference to the various sections under which the laws are severally treated.

The science of chemistry has within the last few years been placed upon a systematic basis founded on the laws of molecules and atoms, called the *atomic theory*. This law was first published by an Italian physicist, Amedeo Avogadro, in 1811; it was afterwards amplified by Ampère in 1814, and may be stated as follows:—The molecules of all gases, simple or compound, occupy equal volumes; or, equal volumes of all gases contain equal numbers of molecules. This is termed the *law of Avogadro*, and is in perfect accordance with the observed fact that all perfect gases, simple and compound, are equally affected by equal variations of pressure and temperature; it is now regarded as affording the most accurate method of determining the molecular constitution of all compounds that can be obtained in the gaseous state, and the atomic weights of the elements contained in them. In order to plainly comprehend the value of this law, the meaning of the word *molecule* must be clearly defined to be the smallest mass into which any substance is capable of being subdivided by physical processes which do not change its chemical nature. Chemistry deals with the relations of different substances which present themselves under the three conditions of the solid, the liquid, and the gaseous state. Some substances, as carbon, are only known in one of these conditions, that of the solid. Others, as alcohol, which so far has never been frozen, assume two of these conditions, the liquid and the gaseous; while others again, as water, appear in all the three states—ice, water, and steam. The meaning and value of the term molecule will at once be comprehended by reference to the substance water. When water is boiled under ordinary atmospheric pressure and converted into steam, it expands 1800 times in volume, which may be stated roughly as 1 cubic inch of water yields 1 cubic foot of steam. This conversion of the cubic inch of water into the cubic foot of steam may be explained in two ways; either that, in expanding, the material of the water has become *completely* diffused throughout the cubic foot of space, in which case the resulting mass of vapour is absolutely homogeneous, every space, however infinitesimal, containing its proper proportion of water; or, that the cubic inch of water contains (as all matter is supposed to be built up of molecules or particles) a certain definite number of particles, which, in the process of boiling and conversion into steam, are separated from one another by the action of heat without subdivision. So that the cubic foot of steam contains precisely the same number of molecules or particles as the cubic inch of water, but at distances infinitely greater apart. Hence the steam is not absolutely homogeneous, as between each particle of water there will exist a space. It is these small masses of water, whose isolation from one another has been assumed, which are what is termed *molecules;* and such molecules have *dimensions* and *weight*.

The undulatory theory of light has of necessity wavelengths of definite dimensions, which have been measured with extreme accuracy, the wave-length being the distance from crest to crest of the assumed ether wave. [See Natural Philosophy.] The solar ray of white light is composed of several rays of different degrees of refrangi-

bility, and of all colours, acting simultaneously upon the retina of the eye. The number and dimensions of these coloured light-waves are:—

Colours.	No. of Waves in 1 inch.	Number of Oscillations in one Second.
Red, ...	39,000	477,000,000,000,000
Orange, ...	42,000	506,000,000,000,000
Yellow, ...	44,000	535,000,000,000,000
Green, ...	47,000	577,000,000,000,000
Blue, ...	51,000	622,000,000,000,000
Indigo, ...	54,000	658,000,000,000,000
Violet, ...	57,000	699,000,000,000,000

Infinitesimal as these individual magnitudes appear, science has yet found the means of measuring them, and although light travels at the velocity of 186,380 miles a second, the magnitudes under consideration are not beyond the limits of mechanical skill or human comprehension. The German optician, Nobert, has succeeded in ruling bands of fine lines on glass plates about 224,000 to the inch, so fine that the most powerful microscopes have failed to resolve them. The same optician regularly supplies plates with from 11,000 to 112,000 lines to the inch for microscopic tests. Now, the lines on the plate with 224,000 to the inch have a sensible distance apart, and yet this distance is not very different from one-half of the mean length of a wave of violet light, or one-third of a wave of red light; the dimensions under discussion are therefore quite within the range of human comprehension. Now, the value of these mechanical bands of lines is that they give a means of measuring the dimensions of the waves of light themselves, and one value of these measurements is that they enable a rough measure to be made of the size of the molecules. The result arrived at is that the magnitude of the molecules—that is, their mean distance from centre to centre—is not very different from the mean length of a wave of light, and that the size is less than the one five-hundred-millionth of an inch. The brilliant colours displayed at any point upon the film of a soap bubble depend on the thickness of the film. The thinner the film becomes bands of colour appear which correspond to a definite thickness of the film, and which are succeeded by others as the film is thinner. These colours are not however pure, but the result of the overlapping of various colours. By employing monochromatic light—that is, light passing through a plate of red glass coloured by copper—all the party-colours vanish, and only alternate bands of red and dark appear. When the film of the bubble is of a sufficient degree of tenuity only a gray tint is seen in irregular patches, and the bubble bursts. The red and dark bands which appeared on employing monochromatic light were caused by the interference of the rays of light, which were reflected from the opposite surfaces of the film. Now, as the path of the rays reflected from the back surface will be longer than that of those reflected from the front surface by twice the thickness of the film of water, whenever this difference of path brings the crests of one set of waves over the depressions of the second set, the union of the two beams of light produces darkness, and such a result can only be produced when the film is of a certain thickness. The theory of light therefore enables the thickness of the film to be measured, and where the gray tint appeared on the film, indicates that its thickness was less than a quarter of the length of a wave of red light, or less than $\frac{1}{156000}$ of an inch. Assuming that water consists of molecules of a definite size, a limit would be reached in the thickness of the film where it was reduced to that of the diameter of a single molecule. Beyond this the film could not be reduced without increasing the distance between the molecules; but to increase the distance between the molecules would be to convert the liquid into a gas, or convert the water into steam, and this effect can only be produced by heat. In order to separate the molecules of a pound of water, or convert it into steam, a mechanical force must be exerted equivalent to 822,000 foot-pounds [see NATURAL PHILOSOPHY—Heat], or a power sufficient to raise 4 tons to the height of 100 feet; and as the weight of a square inch of the film may be readily determined, the force necessary to separate the molecules of which it is composed can be calculated. Molecules may therefore be considered as definite masses of matter, though of exceeding smallness, and molecules are now to the physicist definite units. The term molecule must not, however, be confused with the term atom. In the chemical nomenclature of the present day the two terms stand for wholly different values. The molecule is the unit of the physicist; the atom is the unit of the chemist, in the same way as the earth is taken as the unit of the astronomer.

The law of Avogadro states that all gases contain, under like conditions of temperature and pressure, the same number of molecules in the same volume, and from calculations based on Clausius' theorem of molecular mechanics, this number is estimated at about one hundred thousand million million million (or 10^{23}) to a cubic inch, at a temperature of 0° C. and a pressure of 30 inches of mercury. This law only holds in its integrity when the substances are in the condition of perfect gases, when it is assumed that the molecules are so widely separated that they exert no action upon each other; but the moment the gas is so far condensed that the molecules are brought within the sphere of their mutual attraction, then, although still in the aeriform state, the law no longer holds good, and when by condensation the state of the substance is changed to that of a liquid or a solid the sequence of the law entirely disappears. Every gas is in a state of constant tension; that is, tending to expand indefinitely into space. The tension of the atmosphere is balanced by the force of gravitation, in consequence of which the stratum of the air next the earth is pressed upon by the whole weight of the superincumbent mass, about a ton on each square foot; but exactly in proportion as the external pressure is diminished so the air expands, and the volume varies inversely as the pressure. This, which is termed Boyle's law, is one of the most important facts of physical science, and is most closely related to the law of Avogardo. The molecular theory explains this connection. The molecules of a body are not in a state of rest, but in constant motion. This motion in a gas is assumed to take place in straight lines, the molecules either striking directly against the sides of the containing vessel, or else in their motion coming into collision with neighbouring molecules, and rebounding off in a new direction, according to the laws which govern the impact of elastic bodies. Consequently all the molecules do not move with the same velocity at the same time, but have a certain mean velocity, which determines the temperature of the body. The greater this mean velocity the higher the temperature, and this mean velocity of the molecules of each substance is always the same at the same temperature. This velocity may be approximately calculated for each gas at any given temperature. In the case of hydrogen gas the velocity at the temperature 0° C. is about 6097 feet per second. Two results have now been specified—one, that 1 cubic inch of every gas, with a pressure of 30 inches of mercury and a temperature of 0° C., contains 10^{23} molecules; and another, that the mean velocity of hydrogen molecules, under similar conditions, is 6097 feet per second. Every mass of gas must therefore contain a large amount of internal energy, and if the volume of the gas is diminished, the same number of molecules are crowded into less space, and will impinge more frequently against a given surface, or, in other words, exert a greater pressure. The law of Boyle is therefore the necessary result of the molecular law of Avogadro.

Another effect of molecular motion is temperature. Increased temperature is accompanied by a change of volume, and this change of volume is used as a measure of temperature. The thermometer acts upon this principle. As the volume of a gas depends upon its pressure and its absolute temperature—that is, it is inversely proportional to the pressure and directly proportional to the absolute temperature—the volume of a given mass of gas, under a constant pressure, varies directly as the absolute temperature. This is the law of Charles. The molecular theory of gases explains the law of Charles, as it explained the law of Boyle. The

pressure of gas being due to its molecular energy, if that energy is increased the pressure must likewise be increased in the same proportion; or, if the gas is free to expand under a constant pressure, the volume must be increased. Therefore, the effect of increased energy is the same as the effect which follows increased temperature. From the consideration of this it seems probable that what is termed temperature is simply molecular energy, and that the temperature of a body is the moving power of its molecules. The three laws, therefore, which define the gaseous condition of matter, and which all true gases obey, are the law of Boyle or Mariotte, the law of Charles or Gay-Lussac, and the law of Avogadro. The first two declare that the volume of every gas varies inversely as the pressure, and directly as the absolute temperature (though some of the experiments of Henri-Victor Regnault lead to the belief that the statement of these laws would bear revisal). The third, based on the molecular theory, includes the other two, and enunciates that equal volumes of all gases, under the same conditions of pressure and temperature, contain the same number of molecules.

The chief distinction between liquids and gases is that the former have a definite surface; their particles, though having the same freedom of motion, have this motion restricted to the mass of the liquid. The particles of a gas, if unconfined, would move off indefinitely into space; but those of a liquid cannot, as a rule, rise above what is termed the surface. Air or a gas, when introduced into a vacuum, instantly expands and fills completely the vessel; a liquid, under the same conditions, falls to the bottom, and exhibits a distinct line of demarcation from the vapour which forms above it. Again, when a gas is subject to pressure, it is compressed in proportion to the pressure; when a liquid is subjected to pressure, however great, the reduction in volume is almost inappreciable. Gases are therefore called compressible, and liquids incompressible fluids. This difference of relation between liquids and gases is very simply explained by the molecular theory. In gases the molecules are separated by distances which place them beyond the sphere of each other's influence, and they move through space free from the effects of mutual attraction; in liquids, on the other hand, the attraction (cohesion) is very sensible, and keeps the individual molecules within the mass of the liquid, though they are free to move among themselves. In the mass of a liquid a molecule moves freely, as the attractions are equal in all directions; but as the molecule approaches the surface, the attraction towards the mass of the liquid becomes greater than the attraction towards the surface, and on reaching the surface the whole force of the inward attraction tends to pull it back, and unless the motion of the molecule is sufficiently great it is arrested. On heat, however, entering the liquid some of the molecules may acquire sufficient energy to fly off from the mass of the liquid, giving rise to the phenomena of evaporation. The molecular theory, therefore, explains the liquid condition of matter, and the conversion of the liquid by heat into gas. As all the molecules in a mass of liquid isolated in space are moving with perfect freedom, the extent of the motion of each molecule being limited by the attraction of the mass of the liquid, and as, according to the laws of mechanics, this attraction may be taken as proceeding from a single point within the mass, termed the centre of gravity, the extreme limit of the motions of the molecules to and fro through the liquid mass must on all sides be at the same distance from the central point. The bounding surface of such a mass must therefore be that of a sphere, the form that a mass of liquid always assumes in space. Gases and liquids are distinguished from solids in that they present not the least trace of structure, and are unable to support their own weight or sustain any longitudinal or other stress; solids, on the contrary, have both tenacity and structure, and are able to resist with more or less energy any force tending to alter their form or change their volume. The structure of solids is frequently manifested by their crystalline form, the molecules arranging themselves in some definite position with reference to each other, and forming a distinct structure, depending altogether upon the polarity of the molecules, and their taking up the relative positions which the polar forces require.

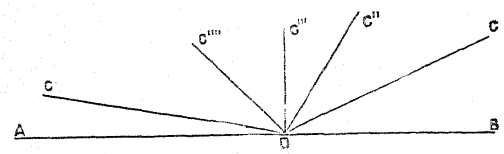
TRIGONOMETRY.—CHAPTER I.

The names of the sciences are usually conferred on them shortly after their birth. They, therefore, necessarily apply to them in a manner which, after their growth and development, seems to us to be strangely inadequate and even inaccurate. A merely etymological definition, though useful, no doubt, as indicating the point of departure taken by a new science, and the earliest conception of it by its originator or first cultivators, is generally rude, vague, and inappropriate to its "larger growth." The genesis of a science is certainly not less interesting than that of a flower, and the root from which the name of a science is derived is serviceable to thought not only as enabling us to mark off the period of its appearance as a thing to be spoken of, but also to suggest the original character in which it appeared to claim the attention of men. Rightly, in ancient times, did the philosophic minds by whom the sciences were pursued and improved determine that the perfection of any form of knowledge consisted in the exhaustive study of every possible element of thought. Their ideal of science was to gather together the smallest possible number of principles into one group, and to deduce from these all the truths they contained or implied. They did not content themselves merely with the surface facts of experience, but analyzed every conception till it yielded up to their inquisitive investigation every secret hidden in it, so far as their research enabled them to probe and prove. The Greek geometricians and astronomers of Alexandria were the inaugurators of trigonometry, which, in its original scope and within the limits of its earlier definition, was geometrical.

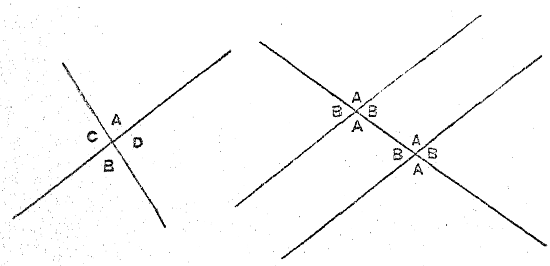
It derives its name from Greek τρίγωνον, a triangle, and μετρέω, I measure; and hence originally, as the derivation imports, signified the art of measuring the sides and angles of triangles. At first an art, and only a very small part of the great science of space and quantity, it rapidly developed a series of distinct and productive truths. These, when collected, formed a science which furnished methods for determining the magnitudes of the sides and angles of triangles. As the study and practice of trigonometry proceeded, its use and scope were extended to the treatment of those theories and problems which arose when considering triangular measurements and magnitudes either on a plane or a sphere. In more recent times the signification of the word, and the purpose and power of the science, have been very largely extended, and now trigonometry includes not only all geometrical considerations arising out of the relations of certain lines holding definite positions in respect to an angle, and varying as it varies, so as to result in what are called trigonometrical functions, but also all such algebraic reasoning concerning lines and angles (whether portions of a triangle or not) as are carried on by means of certain quantities known as the trigonometrical ratios of an angle.

The Euclidean ideal of an angle is that of a point in which two lines having different directions meet—"the inclination of two lines to one another, in the same plane, which meet together, but are not in the same direction;" and a plane rectilinear angle is "the inclination of two straight lines to each other which meet, but are not in the same straight line." A correct apprehension of Euclid's definition of an angle may be made possible by imagining before one a straight line, upon which, at a point not being the end of that straight line, another straight line is made to move as if on a point. That line will form at first a very small angle on one side of itself, and a very large one on its other side. As it is moved onward the angle on the one side will increase, while the other will decrease. So much as is taken from the one is obviously added to the other. The sum of the two angles will always be the same, and the moving line will at last lie flat on the moveless one, and be absorbed in it, so that there will be no angle at all. Let AB be the unmoved line and CD the revolving one, then DC, DC″, DC‴, DC⁗, and DC′′′′′ will represent different positions in the course of its revolution, at which the facts may be observed (1) that the sum of any two angles formed on either side of the line DC, in any one given position—as either DC, DC″, DC‴, DC⁗, or DC′′′′′—or the sum-total of all the angles formed by all the positions of that revolved line, will amount to straightness, *i.e.* will not form

any angle at all. It will be equally plain that in the course of its movements the line CD must arrive at one position, as DC''', where the angles at each side of it will be equal, where it will stand upright, being inclined neither to one side nor another, or be what is called perpendicular. When that is the case we have right or upright angles; for each of the lines stand upright in regard to one another. The size or



extent (or the contents) of an angle depends entirely on the directions of the straight lines which form it. In all cases in which the directions of the two lines by which an angle is formed are the same, the extent or spread of the angle must be the same. The angle which any two lines make when carried on or extended in the same direction, must be the same amount of angle as they formed before they crossed; for it must be noted they now form not one angle only, but that three new angles are formed, in which the angle A equals the angle B, and the angle C the angle D. Parallel lines, so



far as relates to angles, may be regarded as one and the same. If a third line crosses them, the angle it makes with the one will be the same as the angle that it makes with the other; and the alternate angles, viz. A to A and B to B, are also necessarily equal to each other. It makes no difference n geometry and its derivative sciences that one angle may be turned to the right and the other to the left, so long as the direction of the incident lines are the same.

Three lines so meeting that each two form an angle, and that all three inclose a space, form a triangle; and the sum of the angles in any triangle is equal to two right angles. The triangle is the simplest possible figure inclosing a space which can be formed by straight lines. Euclid examines, explains, and proves all the properties of triangles, and as all rectilineal figures, of whatever form, may be reduced to a series of triangles, their properties as inclosures of space and their magnitudes may be found and proved by the determination of the properties and special contents of these triangles. In every triangle there are six things that may be considered—viz. (1) the three sides, and (2) the three angles. In plane trigonometry any two of these and one of the other being given, any one of or all the three other parts may be determined. In spherical trigonometry, however, on any three whatever of these being given, the others may be found, as in it the sides as well as the angles are measured or estimated by degrees, minutes, &c. Right and oblique angles require, of course, different treatment, and yield two distinct sets of formulæ. We might almost say that triangles are regarded by the trigonometrician as the elements into which all figures are decomposable, as words are into letters. They have the smallest possible number of sides, and into them any figure may be, in reality or imaginarily, divided. Their properties and relations have been most thoroughly investigated, and proved with elaborate care by the geometricians. From geometry, trigonometry received and accepted these demonstrations of the properties of triangles; and it devotes itself, in the subordinate position of a servant, to apply the truths it has learned to purposes of utility and the solution of questions of interest, such as the solution, through their aid, of problems regarding height and distance, and the transformations possible in areas of similar content though of dissimilar form, &c. Now it has passed far beyond the mere solution of triangles, plane or spherical, and has investigated and discovered innumerable properties of arcs, angles, and linear angular quantities in simple and complex relations, till by successive improvements it has taken in charge the whole subject of periodic magnitudes, whence it has been able to deduce long trains of consecutive truths. In consequence of these achievements it has indissolubly established itself in an independent position, as a science which is the intermediate and auxiliary of geometry and physics, whose aid is invoked by mechanics, optics, hydrostatics, and astronomy, and whose help is indispensable to the engineer, surveyor, navigator, and architect in their works of peace, and to the strategist, in the operations of fort and field, in war.

A curved line is one which changes its direction so continually, yet gradually, that no part of it, let it be ever so small, can be called straight. The most perfect of curved lines is the circle. The circle is a figure terminated by a curved line, all the points of which are equally distant from *one* point in the interior called the centre. The boundary or encircling curved line is called the circumference. Any line drawn from the centre to the circumference is a *radius*, and the line which, passing through the centre, touches the circumference on both sides is a *diameter*, and is equal to two *radii*.

In selecting a unit of angular measurement, trigonometry sought one the magnitude of which was demonstrably invariable. Geometry supplied the circle as that which naturally and properly afforded the required standard of reference, and circular motion became a primary notion in trigonometrical solutions. An angle which is subtended by an arc equal to the radius of a circle, is that which has been fixed on as the angle of reference. Taking a circle and drawing through its centre to its circumference a diameter, we divide that circle into two equal parts. If we bisect this diameter, and draw through the point of bisection another diameter at right angles to the bisected diameter, we shall have divided the circumference again into two equal parts, and there will be found in the centre of the circle four right angles, and the circumference will be found to be divided into four equal arcs. Every circle is, in sexagesimal measure, divided into 360 degrees. Each of these arcs is therefore 90 degrees, and the stretch or spread of the lines of direction forming a right angle is 90 degrees. Thus the magnitude of a right angle is defined, and its magnitude being known it can be taken as a measure for all other angles. It follows, then, that in one right angle there are 90 degrees, in two 180 degrees, in three 270 degrees, in four 360 degrees, and so on; also that one-half of a right angle is 45 degrees, one-third 30 degrees, two-thirds 60 degrees, and so on. The *complement* of an angle is so much as is required to make it up to a right angle—that is, its deficiency from a right angle, or 90 degrees; and the *supplement* of an angle is its deficiency from two right angles, or what it wants to make up 180 degrees. As the three angles of any triangle are, when taken together, equal to two right angles, it follows (1) that each *acute* angle of a *right-angled triangle* is the *complement* of the other, and (2) that each angle of *any* triangle is the *supplement* of the sum of the other two angles, of whatever sort they may be. The magnitudes of angles are represented by numbers which express how many times any given angles contain a certain angle fixed upon as the unit of angular measurement.

Each degree is divided into 60 minutes (60'), and each minute into 60 seconds (60''). Formerly the second was divided into sixty equal parts called *thirds* (60'''), and so on, but it is now usual to employ decimals of seconds, *i.e.* tenths, hundreds, &c. In this way we can use a decimal notation for the smaller parts of a sexagesimal measurement: *e.g.* Half a right angle contains 45 degrees; a quarter of a right angle, $22\frac{1}{2}$ degrees, 22 degrees 30 minutes, or 22·5 degrees. If, again, we divide a right angle into sixteen parts, one part will be $5\frac{5}{8}$ degrees, that is, 5 degrees 37 minutes 30 seconds, or 5 degrees 37·5 minutes.

In the innovation effected under the influence of the French Revolution, when it was resolved to make all things new, the circle was divided into 400 degrees called *grades*, each degree into 100 minutes, and each minute into 100 seconds; and so on. In this way 12·1329

grades are converted into 12 grades 13 minutes 29 seconds by a mere ticking off of the figures. Even in France, however, the use of the grade obtained only a partial acceptance, and is now almost wholly abandoned, because it involved the throwing out of use the accumulated tables made by former generations, or the loss of the time and labour expended in their reduction. Under the sexagesimal system, the entire angular space or point may be divided into twenty-four aliquot parts, while in the centesimal system only fifteen aliquot parts can be taken. We cannot express in exact aliquot parts in the grade notation one-fifth, one-sixth, one-ninth, one-twelfth, &c., of an angle.

Degrees, minutes, and seconds are, as we have seen, commonly marked °, ′, ″; grades and their subdivisions sometimes thus, ^{g}, \`, \`\`. Thus 38° 17′ 22″ is read 38 degrees, 17 minutes, 22 seconds; $44^g$ 76\` 27\`\`, or $44{\cdot}7627^g$, is 44 grades, 76 minutes, 27 seconds.

Exercise—Read 37° 18′ 22″ 5‴ and 44·7627 or 44^g 76′ 27″.

Rule for the reduction of grades to degrees, and *vice versâ:*

Grades to degrees—multiply by ·9. *Example*—$59{\cdot}145785^g$ = 53° 13′ 52″.

Degrees to grades—divide by ·9. *Example*—59° 14′ 57·85″ = 65^g 83′ 26″.

The accurate definition of terms is of great importance in all studies; but as in geometrical reasoning it is indispensable that we carry with us distinct, clear, and thoroughly understood ideas of the meanings attached to the words we employ, it is as well that these should be placed individually and unmistakably before the mind by precise definitions.

We proceed therefore to supply the student with some special definitions in trigonometry, which he must endeavour thoroughly to understand, and with the names, ideas, and signs of which he should strive to acquire a working familiarity by constant reference from the explanatory *words* to the exemplifying cuts.

1. The circumference of a circle is reckoned to consist of 360 degrees.

2. A right angle is one of 90 degrees.

3. An arc of a circle is called the measure of the angle at the centre standing on that arc.

Hence an angle at the centre is said to be of as many degrees, minutes, and seconds as there are in the arc which is the measure of the angle.

4. A chord is a straight line joining the extremities of an arc.

5. Arcs of different circles which measure the same angle contain the same number of degrees and parts of a degree; for the degrees, &c., in each of them is to 360 degrees as each arc is to its circumference, *i.e.* as the angle which they measure is to four right angles.

6. The sine of an arc is a straight line drawn from one extremity of the arc perpendicular to the diameter passing through the other extremity of it.

The sine of 90° (= the fourth part of the circumference) is the greatest possible one.

7. The versed sine of an arc is the segment of the diameter to which the sine is perpendicular; that is, which lies between the arc and the sine.

8. The tangent of an arc is a straight line touching the circle at one extremity and meeting the diameter that passes through the other extremity.

The tangent of the eighth part of the circumference is equal to the radius.

9. The secant of an arc is the straight line drawn from the centre to the furthest extremity of the tangent of that arc.

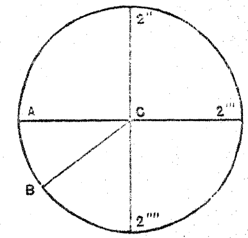
The sine, versed sine, tangent, and secant of an arc are also the sine, versed sine, tangent, and secant of the angle of which that arc is the measure.

10. A versed sine is that segment of the diameter which is intercepted between the arc and its sine.

11. That part of the radius which is between the centre and the sine is the cosine.

12. The sine, versed sine, tangent, or secant of the complements of any arc or angle is called the cosine, coversed sine, cotangent, or cosecant of that arc or angle.

Reverting now to the rectilinear angle, of which we were speaking, we have to remark that the intersecting diameters of a circle form at their point of intersection four right angles. These are called *quadrants*, and in spherical trigonometry *quadrantial triangles* are those of which the quadrant forms a test measurement. As every angle is measured by the circular arc which is described about the angular point with a given radius, a quadrant signifies (1) the quarter of a circle; (2) the arc of a circle containing 90 degrees; (3) an angle measurable by that arc; and (4) the space or area included between this arc and two radii drawn from the centre or angular point to the two extremities of that arc. It is usual to appeal to Euclid vi. 33 for proof of this; but it is quite easily understood by reference to a simple diagram. If with the centre C and radius C A, we describe a circle, A 2″ 2‴ 2⁗, and let the diameters A 2‴ and 2″ 2⁗ be drawn through the centre at right angles to one another, and dividing the whole angular space about the centre into four equal angles, each of these is a quadrant—viz. A 2″, *first* quadrant; 2″ 2‴, *second* quadrant; 2‴ 2⁗, *third* quadrant; 2⁗ A, *fourth* quadrant. And if any other angle is formed by any straight line, as C B, that angle is said to be in the particular quadrant in which the straight line occurs, as A C B in the *fourth* quadrant. As this measurement holds with regard to all the angles of triangles, we may, in speaking of them, use the terms *angle* or *arc* to indicate the inclination with which two lines meet.



But in the higher parts of the science it is by no means a matter of indifference which term we employ. It is evident that an arc can be conceived to exceed, not only half a circumference, but even a whole circumference, or any number of circumferences; while an angle cannot be greater than two right angles. Much obscurity has frequently arisen from neglecting to observe, that when we speak of an angle greater than two right angles we mean merely an arc greater than half a circumference; and that when we consider trigonometrical lines as functions of such an angle, we intend nothing more than that they are functions of the corresponding arc of a circle. Therefore all trigonometrical lines are considered to be functions of the circular arc to which they correspond, the radius being given; and there is no limit whatever to the extension of this arc.

To measure any line, we require to fix upon some unit of linear magnitude or length. Such a unit-line may be trigonometrically represented by P, and two lines which, in relation to one another, are such that the one is contained in the other an exact number of times are called *commensurable.*

As every circle varies in proportion to its radius, the *ratio* or proportion of the circumference of a circle divided by the diameter of the same circle is always the same. The numerical quantity of this ratio, though it cannot be *exactly*, yet it has been *approximately* determined.

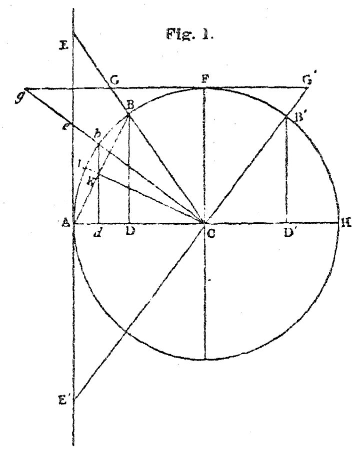
[In most of the following investigations we shall consider the radius of the circle as the unit of linear measure. The semi-circumference is then = 3·141592653590; its logarithm = 0·4971498726; 1 degree = 0·017453292520; 1 minute = 0·000290888209; 1 second = 0·000004848137; their logarithms increased by 10 are 8·2418773675; 6·4637261171, and 4·6855748667. The number of degrees contained in the radius is 57·29577. The ratio of the semi-circumference to radius 1 is generally denoted by π; $\frac{\pi}{2}$ is therefore the value of the quadrant, and 2 π that of the circumference.]

(1.) Let A B (fig. 1 on p. 96) be a circular arc, of which C is the centre, and let C A, C B be joined. The arc A B is proportional to the angle A C B, and either of these can therefore be used as the measure of the other, provided the arc A B is less than half the circumference, or the angle A C B less than two right angles.

(2.) Join A B (fig. 1); draw B D and C F perpendicular to A C; at A and F draw lines touching the circle, which will therefore be parallel to C F, C A; produce C B to cut these lines in E and G. Then A B is the *chord* of the arc A B, B D is the *sine*, C D is the *cosine*, A E is the *tangent*, C E is the *secant*, F G is the *cotangent*, C G the *cosecant*, A D the *versed sine*. D H has been called by some the *suversed sine*.

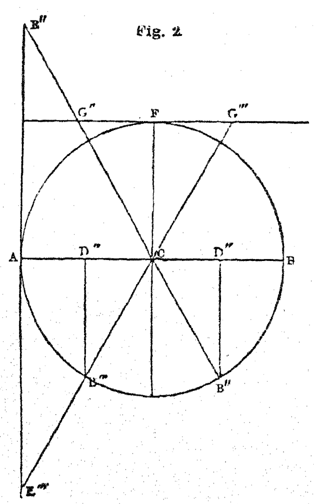
(3.) These definitions suppose the arc to be less than a quadrant. If it be greater than a quadrant and less than a semicircle, as A B′, the same construction gives for the sine the line B′ D′, versed sine A D′, cosecant C G′, cosine C D′, tangent A E′, secant C E′, and cotangent F G′. The four last of these, it will be observed, are measured in directions opposite to those in which the corresponding lines for arcs less than a quadrant were measured, and are therefore considered negative.* We shall show that, by this convention, formulæ which have been found to be true for arcs less than a quadrant may be made to apply to arcs greater than a quadrant.

Fig. 1.



(4.) If the arc be greater than two quadrants, and less than three, as A F H B″ (fig. 2), making the same construction, we find that the sine, cosine, secant, and cosecant are negative. And if the arc be greater than three quadrants, and less than four, as A F H B‴, it appears that the sine, tangent, cotangent, and cosecant are negative. The remark at the end of (3) applies to these. The versed sine and suversed sine are positive for all values of the arc.

Fig. 2.



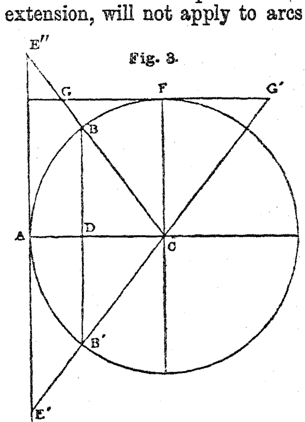
(5.) Thus it appears that, while the arc increases from 0 to a quadrant, the sine increases from 0 to radius (its greatest value), and the cosine diminishes from radius (its greatest value) to 0. While the arc increases to a semicircle, the sine diminishes to 0; and the cosine, whose sign is now negative, increases in magnitude till it = – radius. As the arc increases to three quadrants, the sine is negative, and its magnitude increases from 0 till it = – radius, while the negative value of the cosine diminishes till it = 0. From three quadrants to four the sine, still negative, diminishes its negative value till it = 0, while the cosine, now become positive, increases till it is = radius, as at first.

(6.) The tangent, while the arc increases from 0 till it is $\frac{\pi}{2}$, increases so as to become greater than any assigned quantity; when the arc $= \frac{\pi}{2}$, or $\frac{3\pi}{2}$, there is really no tangent, as the lines, by whose intersection the tangent is defined, do not meet; then, until the arc $= \pi$, the tangent is negative, and diminishes from a value indefinitely great to 0; then, for the third and fourth quadrants the values are the same as for the first and second. And the secant, while the arc increases from 0 to $\frac{\pi}{2}$, increases from radius to a value greater than any assignable; it then becomes negative, and diminishes from a value indefinitely great to radius, which it reaches when the arc $= \pi$; for the third and fourth quadrants its values are the same as for the first and second, with the sign changed.

(7.) If the arc, instead of being = A B, were = A B increased by any number of whole circumferences, the values of the several trigonometrical lines would be the same as those for the arc A B.

(8.) The definitions of the complement and supplement, without some extension, will not apply to arcs greater than

Fig. 3.



90 degrees or 180 degrees respectively. It is only necessary to consider the defect of the arc from 90 degrees or 180 degrees as being negative when the arc is greater than either of those values; and all the theorems relating to these defects will be comprehended under the same formula.

(9.) Since we have considered positive arcs as measured from A towards F, we may consider negative arcs as measured in the opposite direction. Let A B, A B′ (fig. 3) be equal arcs positive and negative; their sines B D, B′D will evidently be in the same straight line; A E′ = A E, F G′ = F G, C E′ = C E, C G′ = C G. Hence for a negative arc, the cosine, versed sine, and secant are the same as those for an equal positive arc; the sine, tangent, cotangent, and cosecant are equal in respect of magnitude, but are affected with different signs. Our figure supposes A B less than a quadrant, but it will be seen that the same is true if A B be greater than a quadrant.

(10.) The whole of what we have assumed with regard to the signs to be affixed to the expressions for lines according to their directions, is purely arbitrary. Its utility is this: a single formula will now comprehend for us several cases for which as many separate formulæ would otherwise have been necessary. This, we conceive, is, in all cases, the true foundation for the use of the negative sign.

* The secant is negative, because it is not measured from the centre in the direction of the radius through the extremity of the arc, but in the opposite direction.

ENGLISH LITERATURE—CHAPTER II.

THE ANGLO-NORMAN PERIOD.

THE second historical epoch in the development of the language and the progress of the literature of England may conveniently be called the Anglo-Norman Period. It lasted upwards of two centuries and a half, and includes in its record a narrative of that long struggle in which the conquered English and the conquering Norman measured the might of resistance against that of oppression. From the days of Athelstan, the first officially recognized king of England, in whose reign the battle of Brunanburgh was fought, the invasions of the Danes had been a perpetual trouble. Various measures, all of which, however, proved insufficient, had been taken to prevent their inroads and assaults. Even the payment of danegeld—a tax which on one occasion amounted to 50,000 lbs. of silver—failed to secure immunity. Ethelred resolved on a terrible expedient. He ordered the massacre of all the Anglo-Danes. On 13th November, 1002, this command was partially obeyed, and Sweyn, raging for reprisals, ravaged the country for many years. After his death Canute took up the quarrel, and carried on a retaliative war against Ethelred and his son and successor Edmund. In this he was successful. On Edmund's death he married Emma, sister of the Duke of Normandy, Ethelred's widow. Thus he got Edward and Alfred, Ethelred's sons, into his power. He sent Edmund's two boys out of the country. Then he assumed the throne. The National Council admitted his claim, and he governed as King of England. He was, while sovereign, converted to Christianity. He reformed many abuses and framed some good laws. On his death, 1035, he left the throne of England to Hardicanute, his son by Emma, but Harold (Harefoot) seized and held the sovereignty for a time. He died 1040, and Hardicanute then acceeded to the crown. On his death, 1042, Edward, son of Ethelred and Emma, became sovereign of the English and the Danes. Danish invasion ceased, the danegeld was abolished, and Edward was very popular. But having been long brought up in the Norman court, and having made many friendships there, he, by appointing Normans to all the high offices of church and state, displeased the Saxon nobles, and a revolt occurred. He had, it is said, promised that William, duke of Normandy, should be his successor on the throne. Harold II., prior to his usurpation of Edgar Atheling's crown, had also pledged himself to favour William's ambition to be king of England. On Harold's accession William remonstrated, and prepared to enforce his claim by war. He sought and gained the Pope's sanction for his enterprise. Shortly afterwards William landed on the coast of Sussex, and at the battle of Hastings won the kingdom he coveted. He was crowned at Westminster by Aldred, archbishop of York, on Christmas Day, 1066. No sooner was he established on the throne than he confiscated the estates of the Saxons and conferred them on his Norman followers. In a seven years' war the Saxon patriots resisted. Seeking the help of the Danes and the Scotch in 1070, they made strong efforts against oppression, but William laid waste 60 miles of territory north of York, bribed the Danes, and drove the opposing forces into hiding among the Lincolnshire fens, where, under Hereward, the national struggle was continued till that hero was betrayed by the monks of Ely in 1072. Having slain, degraded, or exiled the native nobles and prelates, and placed in all high offices of church and state his Norman kinsmen and helpers, the Conquest was achieved. William claimed to be the owner of all the land in the kingdom, and no man possessed any property unless it was held under him, on oath of fealty and promise of feudal service, *i.e.* military supplies of men-at-arms, faithful counsel in national affairs, and pecuniary *aids* on demand. The landlords held *in capite* and their tenants *in feu*. The Saxons were *villeins* and *churls*—as the peasantry and the sturdy labourers of the land were called. These were under the government of the barons, who managed the affairs of their own estates, and had the privilege of using them in the waging of private war against their personal enemies, and of selling them into slavery along with any land of which they might dispose. The landholders and their tenants were made mutual defenders of the state against external enemies, and thus there grew up, at length, a sense of national unity under a supreme sovereign. England became, what was to be found nowhere else in all Europe, a solid state, with a central authority—a land wherein rights and duties, even struggles and sufferings, were so arranged as, in the long run, to tend towards the welding of the inhabitants into a state, a nation.

While William, in England, was laying the foundations of a firmly-built feudalism in the state, Hildebrand, as Pope Gregory VII., was engaged in an endeavour to raise the church into an independent spiritual kingdom—in which self-sacrifice would be service. The world founded families, and feudalism established them; the church should form but one family, and by cutting itself off from all the temptations of human nature, should use the whole machinery of clerical wealth and power in organizing a counterbalancing organization to merely feudalized states. No layman's touch should defile the clerical sanctity of the priests of God; church offices and property, churchmen and church laws were to be independent of the state. He and his successors should rule the world as the representatives of Him to whom "the kings of the earth" must yield submission. The self-willed barbarians, whose only thought in life was to gratify the passion of the present hour, must be taught by the armies of the church—men of culture, learning, self-restraint, and disciplined power—to feel, know, and yield to the great universal commonwealth of moral and religious power, the papacy. The church became the rival of all states, and claimed lordship over all.

The English clergy, before the Conquest, were husbands and fathers of families, and had a place among the people. Bishop and alderman jointly administered law at the shire-mote, and church and state were intimately related. The Norman churchmen brought in the sterner discipline of Gregory, and insisted on the introduction of canon law. William used the churchmen of his time as agents in his conquest, brought over learned men to fill the sees of England, established schools for the training of clergy and laity; and under himself and his successors some of the finest of the cathedrals of England were erected. Churchmen became the promoters of learning, arts, and literature in the land.

These ecclesiastics were most of them monks. Their entire spirit was subdued to sacerdotalism. They looked upon the insular Saxon priesthood as lax in discipline, loose in morals, secular in sympathy, and untrained in scholastic subtleties. As means of reforming the church, the dismissal of the Saxons from their sees, and the filling up of their places by Normans from the universities and monasteries of the Continent, were resolved upon. St. Wulfstan of Worcester, Agelric of Chichester, and a few others were permitted to retain their mitres; but by far the greater part were dispossessed. Besides this, it was ordained "that no Saxon monk or clergyman should be suffered to aspire to any dignity whatever." The Saxon clergy were thus deprived of the wholesome stimulus of ambition, and such of them as felt the stir of aspiration in their hearts found it most advisable to surrender their Saxon leanings and acquire Norman proclivities.

Habit, which is second nature, had made Latin the every-day speech of the ecclesiastics. Those who were brought into frequent intercourse with them, those who were trained in their schools, and those who sought knowledge under their guidance required therefore to study Latin. Those who held lands, office, or service under the Norse nobles; who laboured under their oversmen, or sought to regain aught by their help, found French stand them in most stead. It was only among the churls by the cottage hearth, on the village green, in the harvest fields, or in the alehouse that Saxon was the language of life. There arose, therefore, by the inevitable necessity of things, a threefold literature in the land—(1) The Latin of the clergy and their friends and followers; (2) the Norman-French of the barons and their dependants; and (3) the Saxon of the songs of the wandering minstrel and of the folk-tales of the peasantry. Latin is stately, formal, and sinuous; French adroit, polished, and distinct; Saxon blunt, vigorous, and expressive. These were the elements which came to be moulded and formed into a national speech which should utter forth the whole mind and feeling of the people.

Latin continued to be the language of theology, philosophy, history, and science; French was the chosen vehicle of

romance and poetry, of legislation and courtly grace; Saxon was the lower colloquial medium of daily conversation among the common folk; but the intricate symmetricality of Latin sentences, the artistic fitness of form for which French was acquiring distinction under the workmanlike manipulation of the *Trouvères*, were yet to be amalgamated into a new compound—English—in which the force, energy, and pith of the speech of the churls should impart its enduring vitality to the associated solidity of Latin and the unshackled yokelessness of French. It is that we may trace the growth towards unity of this threefoldness of speech, that, classing all the literature of the age as Anglo-Norman, we notice each in succession as it makes approaches towards the fine resulting product of English literature.

Of writers in Latin prose we need only name the Italian Archbishop of Canterbury, Lanfranc (1005–89), one of the early founders and expositors of the scholastic philosophy, and an orthodox dialectician of great subtlety, as any one may see who reads his "Elucidarium, sive Dialogus summam totius Theologiæ Complectus" (Explanation, or a Dialogue embracing the sum of all Theology), which was long attributed to his disciple Anselm, or his "De Sacra Cœna," in opposition to Berengarius; Adelard of Bath (flourished 1100), the philosopher of England, who sought knowledge in Greece and Asia Minor, and brought it, in Henry I.'s time, by his "Questiones Naturales," "De Eodem et Diverso" (About Sameness and Difference), &c., into England, where he taught the abacus and the astrolabe; and John of Salisbury (1120–80), pupil of Abelard, friend of A'Becket, and secretary to Theobald, archbishop of Canterbury, an elegant and erudite author, who opposed the narrow scholasticism of his age, and advocated classical studies.

Another series of English writers of Latin books demands a little more space:—

St. Anselm, born at Aosta, in Piedmont, 1033, was induced by Lanfranc in 1060 to enter the Monastery of Bec, in Normandy. Of it he was made prior in 1063 and abbot in 1078. In 1093 he was Archbishop of Canterbury, and remained so till his death in 1109. His earliest work was, probably, a "Dialogus de Grammatico," in which he contends that a grammarian is in substance a man and in quality a person versed in a knowledge of words. In his "Dialogus de Veritate" he maintains that truth exists *per se* in God, and is shadowed into the soul of man from him, and becomes predicable by man as intellectual experience in being and action. His "Proslogion" is an *a priori* argument for the existence of God. In his "Cur Deus Homo?" (composed 1094–98, and republished in 1863) he gives an exposition of the philosophy of the plan of salvation; and in his earlier "Monologion" (1070?) he discusses the theory of the good and the true. Of his "De Vera Religionê" the chief idea is that without faith there is no experience, without experience knowledge is impossible. It is the duty of everyone to gain knowledge as far as his capacity permits; but the *credo* of the church is the absolute law of faith, and all seeming knowledge negative of that is false and sinful.

Alexander Hales (died 1245), "the Irrefragable Doctor," "the Fountain of Life," a divine and a philosopher, was the first of the scholastics who knew the whole philosophy of Aristotle and the commentaries made by Arabian thinkers upon it. In his "Summa Universæ Theologiæ" he makes use of the doctrines of philosophy to explain and enforce the dogmas of theology. This work was composed by command of Pope Innocent IV. Hales also wrote some valuable "Commentaries on the Scriptures," and had as one of his pupils St. Bonaventura, "the Seraphic Doctor," through whom a number of his opinions were communicated to St. Thomas Aquinas, who reproduced and illustrated them.

No name in the world's history at this time is more deserving of admiring note than that of the Franciscan monk, Roger Bacon. He was born near Ilchester, in Somersetshire, 1214, and died in 1292. Of an ancient and excellent family, he was educated at Oxford and Paris. He had, in his early career, Clement IV. for his patron. He was a scholar in Greek, Hebrew, and Arabic, and his studies extended to mathematics, mechanics, optics, astronomy, physics, metaphysics, and philology. Not from want of energy or will, but from the torpor and ignorance of his times, he failed to become the reformer of philosophy. He was the earliest philosophical experimentalist in England; and a large amount of actual discovery rewarded his laborious research. Personal observation of nature and well-planned experiments in science distinguished him from the sciolists of the schools. His method was called magic and his investigative zeal obnoxious heresy. He had no irrational deference for authority, no slave's supple respectfulness for custom, no specious flatteries wherewith to conciliate prejudice. He sought truth through carefully arranged research. He made discoveries in chemistry and optics. We owe the invention of gunpowder to one of his experiments, and to him there came a hopeful dream of traversing both sea and land by the agency of steam. He wrote on the secret processes of art and nature, on the uselessness of magic, and he provided for men's use the mirror of alchemy and the mirror of secrets. His "Opus Majus," "Opus Minus," and "Opus Tertium" are works of special excellence for his age. Yet he was twice imprisoned, and on the latter occasion he lay immured for ten tedious years. His monkish brethren, the Franciscans, disliked him for striving to divert the interest of his contemporaries from the subtleties of speculative theology to the divine mysteries of nature. He stood in the forefront of the thinkers of the thirteenth century, and adumbrated the keen-eyed Verulamian Bacon who adorned the glorious days of England's Elizabeth.

Of John Duns Scotus, "the Subtle Doctor," the three Britannic kingdoms each claim the honour of having been the birthplace—Down, in the north of Ireland; Dunston, in Northumberland, England; and Duns, in Berwickshire, Scotland. In the Franciscan order, of which he was a member, he was a distinguished teacher and controversialist. He was acute in negative criticism rather than able in the elaboration of positive speculations. His great fame was gained by his dispute with St. Thomas Aquinas, out of which arose the schools of the Thomists and the Scotists. The latter school did not put reason and faith in antagonism, but held rather that reason could not demonstrate, though it could defend, the truths which revelation disclosed. His "Positiva," or Commentaries on the Bible, are reputedly ingenious and interesting. His philosophic and dogmatic works occupy twelve folio volumes, and have been published under the care of the Irish fathers of the Roman College of Isidorus, and so important are his contributions deemed to human thought that many expositions of his doctrines have been prepared not only in separate books, but in all the larger histories of philosophy.

William of Occam, "the Invincible Doctor" and "the Venerable Originator," was a brave diver into the depths of divine philosophy and diviner theology. He was born at Oakham, in Surrey, became a Franciscan, a pupil of Scotus, and a teacher in Paris. He argued against the domination of the Pope in temporal affairs. From the pursuit of the holy father he fled to Ludwig of Bavaria, and besought protection, saying, "Defend me by thy sword; I shall defend thee by my words." His aim was to distinguish between reason and faith, to determine their relative place and power, and to make possible an inductive investigation of external nature, as well as a deductive inquiry into revealed truth.

We pass now from our philosophers to our historians.

The old chroniclers of our country's history are indeed numerous, varied, and usually informing. Essential facts are presented clearly, and essential principles are placed alongside of them. The monastic character of most of them appears in their constant reference to Scripture and religion as bearing upon the events they narrate as exemplary or explanatory. If they are less courtly in phrase than the antique chroniclers of France, they are more national and patriotic, more sympathetic with the people and their progress in temporal prosperity and spiritual intensity of character. Unitedly they supply a body of historical records of the early times of Britain's existence such as may well be called matchless for variety, interest, and voluminous industry in compilation. They are important and valuable, as they contain the narration of the circumstances of the shaping of early England's thought, speech, and life.

English literature had no standard language, accepted by the entire land, between 1160 and 1360; and for nearly a century prior to the earlier date English had been giving place to Latin influences and French encroachments. About the close of the thirteenth century, however, the language of the conquerors and the conquered formed a new flowerage of speech, and an English national literature became possible. The baron's hall and the knight's castle were the resort of the gleeman and the story-teller. The fine imaginative legends of ancient Britain, which had been floating traditionally among the valleys that lay embosomed in the Welsh mountains, impressed the mind of Geoffrey of Monmouth, bishop of St. Asaph, author of a "Chronicon or Historia Britonum," and led him to give them literary embodiment. His "History" has been the treasure-house of innumerable romances. He gave the cue to Wace and Layamon; he supplied the raw material of Mapes' "Holy Graal;" of Sackville's "Gorboduc, or Ferrex and Porrex;" of Shakspeare's "Lear" and "Cymbeline;" of Drayton's "Polyolbion;" of Milton's "Comus;" and of Tennyson's Arthurian poems. Pope at one time meditated taking his "Brutus" as the theme of a real national epic, and many of our dramatists owe to his vivid pages the germs of their plots. He is the chief of the chroniclers. If he did not create, he at least revived these wondrous fables, and provided not only an exhaustless fund of "storial thing" for the minstrel in the banquet-hall or the peasant by the hearth, but gave a living power and secured a lofty place for the chronicle as a form of literature. There were, of course, historic chroniclers in the Saxon times. These, however, were mainly historians and annalists; but he transformed the chronicle into a record of the land of fairy and fancy, and impressed the scholarly grace of learning on the rude imaginings of the Cymric genius. He created a new style of literature—historic fiction—and made the task of the minstrel lighter and brighter. Into all lands went the tales of the Monmouth narrator, and the pleasant poetry of his "History" has made itself felt everywhere.

A great many other chroniclers and historians flourished in Norman England. Most of them were ecclesiastics, who lived monastic lives and wrote in Latin. Of these, Marianus nus Scotus (1028–86), following Cassiodorus, Eusebius, and Bede, epitomized history from the creation till 1083; Ordericus Vitalis (1075–1142) in thirteen books narrated the chronicles of the church at large, the story of the Abbey of St. Evroult (of which he was a brother) in particular, and the secular events of Normandy and England, as interlaced by the Conquest, in a quaint digressive style, full of anecdote, fancy, and naïve remarks; and Ranulp Higden (sometimes called Randal Higginet, and supposed to be the author of several of the Chester mystery plays), composed the "Polychronicon," a history of the world, in seven books. In these respectively Higden (1) describes the countries of the world, especially Britain; (2) narrates the history of time from the creation till the era of Nebuchadnezzar; (3) carries on the story till the death of Christ; (4) continues it to the arrival of the English in Britain; (5) proceeds with details to the invasion of the Danes; (6) brings down the record to the Conquest; and (7) journalizes events till 1342. He died twenty-one years thereafter.

Few of our other historians went so far afield. For the most part they contented themselves with the records of their own times and country. At the court there were encouragements and rewards for wits and eulogists; in the cloisters there were secular and ecclesiastical interests evoking statement and comment; in the schools there were men to whom a retrospect of history was regarded as philosophy teaching by example, and who thought that current history might be better understood when the record of the experiences of centuries were placed before the mind; and the annual chronicle of the conventual establishments still received the jottings of events and incidents of interest to the great body of the people or to the select community, whose journal it was.

The record given in the "Saxon Chronicle of Peterborough" of the reign of the Conqueror's grandson, Stephen—that "in his time all was dissensions, and evils, and rapine," is supported, so far as his history reaches, by William of Malmesbury. In the "Gesta Stephani," however, an unknown author of the same period has written a vivid and valuable account of the civic warfare of that age, which, though favouring Stephen's party, fills up the outline of the fourteen years' commotion between the Empress Maud and her usurping cousin, left unfinished by the famous historian of St Maidulf's monastery.

Of the reigns of William II. and Henry I. the most valuable account we possess is found in the "Historia Novorum," by Eadmer, the trusted and trustworthy follower of St. Anselm. It extends from the Conquest to 1122. Ingulphus (1030–1109), abbot of Croyland, an abbey founded by Ethelbald, king of Mercia, has had attributed to him "The Chronicle of Croyland," which consists, in great part, of an account of that Lincolnshire religious community, who were housed on the site of the cell of St. Guthlac, over which he presided: though it is in some measure a history of the kingdom as well as of the monastery. His part of the work ends in 1090, and the continuation is due to Peter of Blois, archdeacon of Bath. In scarcely any of our early chroniclers are there to be found so many curious incidents noticed as in this work. By Sir Francis Palgrave serious doubts have been raised regarding its accuracy and authenticity. Simeon of Durham, in his "Historia de Gestis Regnum Anglorum," in the midst of much matter taken directly from Florence of Worcester, introduces interesting notices of affairs in the north, not mentioned elsewhere. The "History of the Church of Durham," which bears his name, has been attributed to a monk named Turgot; but Thomas Reed, his editor, asserts Simeon's claim to the authorship. The Florence of Worcester on whom Simeon relied founded his history on the chronicle of the Irish monk, Marianus Scotus, Bede's "History," Asser's "Alfred," and "The Saxon Chronicle." From the creation to his own times, Florence epitomizes their writings, but he preserves and passes on to us a number of facts relating to Worcester and Wales which are known to us only through him. After his death, on the nones of July, 1118, John of Worcester took up the story and continued the chronicle to 1141; and a sequel, beginning in 1152, which carries the narrative down to 1295, has been supplied by two anonymous monks of Bury St. Edmunds.

Professor Stubbs regards the Chronicle ascribed to Benedict, abbot of Peterborough, as only transcribed by his orders, and that the compiler is probably Richard Fitznigel, treasurer to Henry II., and author of a "Dialogue concerning the Exchequer." It is arranged with care, judiciously composed, contains many copies of official papers, and is of great value as a record of the reigns of Henry II. and Richard I. It extends from 1177 to 1193. Richard of Devizes adds to the information regarding Richard I., from 1189 to 1192, in a chronicle written at Winchester. An epitome of Geoffrey of Monmouth's "History" and two historical collections relating to the years 1147–1202 are due to the pen of Ralph de Diceto, dean of St. Paul's, London, a friend of Canon Mapes. Roger of Wendover, prior of Belvoir and monk of St. Alban's, in his "Flores Historiarum" (Flowers of History), has gathered together for us a number of excellent extracts from works now unknown, and given an account of his own period, reckoned of much historical worth. It closes in his death-year, 1237. Thomas Wikes, an Augustine friar and canon of Oseney, has summarized events of the period 1066–1260, and supplies for the twenty-nine years thereafter a copious historical record. Gervase of Tilbury, Essex, reported, for the Emperor Otho IV.'s leisure, in his "Otia Imperialia" many of the tales and superstitions of the middle ages; and Gervase of Canterbury supplies, with considerable fulness, notices of the lives, times, sayings, doings, contests, and conquests of the primates of England under Stephen, Henry II., and Richard I.

Robert of Gloucester, in the days of Henry III. and Edward I., wrote in English rhymes the "Chronicles of England," in which he introduced most of the fables of Geoffrey of Monmouth, in terms which, though in metrical form, were even less poetical in language than Geoffrey's prose. It begins with the (imaginary) Brutus and comes down to the time of Henry III. From an allusion made in it to the canonization of St. Louis of France we learn that this poem was composed about 1300. His narrative is very minute and

accurate in topography, as well as in story. He uses in it the speech of the burghers, woodmen, and peasantry of his age, and affords much information concerning the social condition of England, and many illustrations of the manners and customs of the writer's contemporaries. He has been designated England's Ennius—the first who traced the history of his native land, from its far-away fabulous sources, into the living light of his own day. He gives us this note of the speech of England in the early part of the reign of Edward I., 200 years after Harold's defeat—

"Thus come, lo! Engleondé into Normannes bonde,
And the Normans ne couthe speke tho bote her owe speche,
And speke French as dide at ome; and here chyldren dide al so teche
So that hey men of this lond that of hei blod come
Holdeth alle thulke speche that hii of hem nome.
For bote a man couthe French men tolth of hym wel lute;
Ac lowe men holdeth to Englyss and to her kunde speche yute,
Ich wene ther be ne man in world contreyes none
That ne holdeth to her kunde speche, but Englelond one.
Ac wel men wot for to coune bothe, wel yt ys,
For the more that a man can the more worth he ys."

This may take the following modernized form:—

"Thus came, lo! England into the Norman's bond[age],
And the Normans could not speak then but their own speech ["ne . . . bote," equal to only],
And spoke French as [they] did at home; and their children did all so teach.
So that high men of this land, that of their [Norman] blood came
Hold [by] all the same speech that they of them took [niman, to take].
For but [equal to unless] a man could [speak] French, men tell [count] of him well little,
And low men hold to English and to their kindred [native] speech yet.
I ween [know] there is no man in world-countries none
That holdeth not to their kindred speech but England [al]one.
And well men wot for to know both, well it is,
For the more that a man knows the more worth he is."

Good Latin poetry prevailed among the prelates, priors, and priests of the twelfth century. This was the era of Leoninus, from the popularity of whose measures a certain kind of rhyming Latin verses are called *Leonine*. Though he was an adept at this jingling of syllabic sounds, he composed twelve books of Bible history in regular heroic verse. Laurence, prior of Durham—"a dull Latin Cædmon," Henry Morley calls him—wrote in hexameter and pentameter verse "Hypognosticon," a paraphrase of Scripture incidents in nine books, six devoted to Old Testament events, one to the Virgin Mary, one to the gospel narrative, and the last to the saints and martyrs of Durham, in which the remarkable story of the peregrinations of the bones of St. Cuthbert during many centuries before they found their resting-place on the slope of Dunholme receives due prominence. Henry of Huntingdon, who was an able chronicler as well as a voluminous poet, composed eight books of epigrams upon love, two books on aromatics and gems, and one on weights and measures. These and other works he collected and transcribed, before he died, in twelve books, of which two MS. copies are extant. John of Salisbury wrote, in 1156, "Polycraticus," a contrast between followers of worldliness and students of wisdom. This was a popular book for centuries, and was printed in 1475. He is also author of a satirical defence of scholastic logic against courtly trifling, and more than 300 of his letters have been preserved. He holds a place among the logicians from his essay on the value of logic, "Metalogicus." Perhaps Nigel Wireker, a benedictine of Canterbury, had the logicians, of whom this John was the satirist, in his thoughts when he produced his "Brunellus" or "Speculum Stultorum" (The Mirror of Fools). In fluent elegiac verses he, in a satirical fable, derides those who, especially monks, are not contented with their estate in life and seek advancement or preferment by any means, however wrong, under the figure of an ass who is discontented with the length of his tail, and makes every effort possible to get a new and longer one. In the course of his wanderings Brunellus endures many adventures and disasters. At length he goes to the University of Paris and mingles with the English students, who formed one of the four schools or nations thereof. Having acquired science he seeks religion, and wanders among the monastic orders in quest of it. University and conventual life are mercilessly discussed, and at the end he asserts contentment, truthfulness, and holiness to be the best things for all who aim at doing life's real duties rightly. Alexander Neckham—punningly nicknamed "Nequam," good-for-nothing—foster-brother of Richard I., not only wrote tractates on theology and abstracts of Aristotle, but put science into song in ten books of elegiac poetry. Of the Crusades we gain the earliest historic record in Fulks or Fulco's Latin narrative, which he left unfinished, in three books. They brought the account up to the siege of Nice. Here Gilon took up the thread of the story and carried it on to the coronation of Godfrey. Monachus Florentinus wrote 900 quatrains on the "Taking of Acre," and in praise of

"Rex Angliæ inclytus Richardus
Qui per famam, redolet ut odore nardus."
(The illustrious King of England, hight Richard,
Who, in high renown, smells like the odour of nard.)

Walter de Mapes rhymed his Latin lyrics with felicitous humour and metrical skill. He was chaplain to Henry II., held many preferments, and was prebendary of St. Paul's. At the instance of his royal master he translated from Latin into French the popular romance of "Saint Greal" (Sanguis-realis), the sacramental cup which our Saviour used at the Last Supper, and which Joseph of Arimathea preserved, because in it was caught the blood that flowed on Calvary. The original MS. of this version forms part of the literary treasures of the British Museum. Mapes was of Cymric descent, and born on the borderland of Wales. He had studied under Girard la Pucelle in the University of Paris, and shared in the conflicts of "town and gown." He was at once scholar, wit, and ecclesiastic, a lawyer, a politician, and a patriot. He has been called "the jolly Archdeacon of Oxford" and "the Anacreon of his age;" but these ready-made labels almost imply libels. He was a most sincere believer in and seeker after truth and righteousness. In his "De Nugis Curialium" (On the Trivialities of Court-life) we have much of the gossip of fashionable society, anecdotes and scandals, table-talk and serious notes on the circumstances and incidents of his time. It is a sort of common-place book of the sayings and doings which attracted attention in his circle, and which he had learned to think remarkable, and it is intentionally so written that the telling should be pleasant and the instruction should tend to morality. He was full of holy earnestness, and men mistook his scathing satires of loose-living friars for real expositions of his own inordinate relish for fleshly delights and the pleasures of wine-bibbing. Golias, in whose name he writes—and writes so vividly that men have declared him to be a real author and a living person—is only a clerical Falstaff whom Mapes makes use of as a mark for moral scorn on account of his fleshliness. The following sprightly verses have often been quoted, apart from their serious context, as a wildly hilarious song. It is rather a confession wrung out of a sad soul in, as Henry Morley says, "the candour of despair."

"Mihi est propositum in tabernâ mori,
Vinum sit appositum morientis ori,
Ut dicant cum venerint angelorum chori,
'Deus sit propitius huic potatori.'

"Poculis accenditur animi lucerna,
Cor imbutum nectare volat ad superna,
Mihi sapit dulcius vinum in tabernâ
Quam quod aquâ miscuit præsulis pincerna.

"Suum cuique proprium dat natura munus.
Ego nunquam potui scribere jejunus;
Me jejunum vincere posset puer unus,
Sitim et jejunium odi tanquam funus.

"Tales versus facio quale vinum bibo;
Nihil possum scribere nisi sumpto cibo,
Nihil valet penitùs quod jejunus scribo,
Nasonem post calices carmine præibo.

"Mihi nunquam spiritus prophetiæ datur
Nisi tunc cum fuerit venter benè satur;
Cum in arce cerebri Bacchus dominatur,
In me Phœbus irruit ac miranda fatur."

We subjoin a spirited translation (slightly altered) by Mr. Derby, of Fordingbridge, in Hampshire—

"I'm resolved in a tavern when fated to die:
At my mouth place a full flowing bowl,
That angels, while round me they hover, may cry,
'Peace, O God, peace to this jolly soul!'

"By toping the mind with fresh vigour is fraught,
The heart, too, soars up to the skies;
Give me wine that's unmixed—not that watery draught
Which the president's butler supplies.

"To each man his gift, Nature gives to enjoy,
To pretend to write well is a jest
When I'm hungry; I yield, overcome like a boy
And a fast like the grave I detest.

"My verses all taste of the wine that I stow;
While I'm empty my muse is unkind;
But, with bumpers enlivened, how sweet does she flow!
Fam'd Ovid I leave far behind.

"Till my stomach's well filled, truths I ne'er can divine;
But when Bacchus holds rule in my pate,
The strong impulse I feel of the great god of rhyme,
And wonderful things I create."

Mapes' excellent "Dialogue between the Body and Soul" of a condemned person, disputing between themselves as to which was the real cause of the woes they experienced, is very able and duly serious. It was greatly relished by his contemporaries, and an imitation of it, "The Body and the Soul," in Saxon measures, reads like a genuine original production, and is almost English in its vocabulary and collocation.

Raginaldus (died 1122), an English monk, house-governor in the Augustine monastery at Canterbury, wrote in the time of William the Conqueror "The Life of St. Malchus," in six books. It is founded on a work attributed to St. Jerome, of the statements in which La Fontaine has given a versified abstract. Malchus, an only son, was by his parents enjoined to marry, and fled from his father's house to Nisibis, in Mesopotamia, where he became a hermit. He, being tempted from his cell by desire to see the world, was, on his way to Edessa, made captive by the Saracens. The master to whom he was assigned compelled him to marry a woman whose husband had been allotted to another master. He was a shepherd, she a shepherdess. They vowed to live an unpolluted life, and did so. Ultimately they escaped by night, but their master, being skilled in magic, pursued them. They were found in the cave of a lioness. The lioness slew the master. They made their way to Malchus' home-land, and there they settled in a garden, vineyard, and shrubbery, where content and peace were found. Here he was visited by St. Jerome, and to him his true history is related. This poem, of 3390 lines, is composed in flowing and varied forms of verse. It contains a strange mixture of pagan and Christian allusions; includes, in an address to the Deity, an abstract of Bible history in three-lined rhymes; in a description of the palace of old father Oceanus, an epitome of mythology, and a condensed view of all the wisdom of his age in arts, sciences, ethics, and philosophy. There are in it odes to Venus, epodes to Satan, addresses to Hercules, and to many of the heathen gods, hymns to the Holy Spirit, prayers to the Virgin, praises of St. Jerome, and lowly adorations of Jesus. The versatility of style, metrical mastery of intricate prosodiacal measures, copiousness of reference and language, mark Raginaldus as one of the most cultured and full-minded of those who gave poetic form to original thought in Latin rhythms.

A Latin poem ascribed to St. Bernard and to Pope Clement, entitled "Floretus," treating of faith, morality, and the religious graces, was translated into French by William of Waddington, Yorkshire, and rendered into English verse in 1303 by Robert Mannyng of Brunne or Bourne, in Lincolnshire, under the title of "The Handlynge Sinne." This book is full of "tales and rhymes" intended to warn from "deadly sin or other folly." It rehearses the Decalogue; illustrates and enforces each commandment with some story; describes, denounces, and admonishes the avoidance of the seven deadly sins; details and commends the observance of the seven sacraments, and closes with the twelve graces of thrift. Its pictures of social life are vivid and quaint, striking and apt. In it, as in his rhyming Chronicle (versified from the French of Langtoft), he writes, as he says, "not for the learned but the lewd" (untaught).

Geoffrey de Vinsauf, Galfridus de Vinosalvo, or "English Geoffrey," a scholar of Frides-Wide, and a graduate of the Universities of Oxford, France, and Italy, wrote a long critical didactic hexameter poem, "De Nova Poetria," which he dedicated to Pope Innocent III. In it he recommends, by precept and examples, recurrence to classical measures and abstinence from Leonine verse. Other works on ethics and rhetoric are attributed to him. The "Itinerary of King Richard"—though probably not his—has been ascribed to him, and perhaps merits reference here as a poem to which, two centuries afterwards, another English Geoffrey (Chaucer) ironically alludes. Richard I. died on Friday, 6th April, 1199, and Geoffrey says—

"O Veneris lacrimosa dies! O Sidus Amarum!
Illa dies tua nox fuit, et Venus illa Venenum,
Illa dedit Vulnus," &c.

Chaucer, speaking of the killing of a domestic cock by a fox, thus ridicules this in "The Nonne's Priest's Tale."

"And on a Friday fell all this mischance.
O Venus, that art goddess of pleasaunse,
. . . .
Why wouldst thou suffer him on thy day to die?
O Gaulfride, dear master sovereign!
That, when that worthy King Richard was slain
With shot, complainedst his death so sore,
Why ne had I now thy science, and thy lore,
The Friday for to chiden, as dide ye!
(For on a Friday soothly was he slain)." (521–532)

Latin poetry, however quick to the mind of the student whose converse was with books composed in the Roman tongue, and whose conversation was with those who understood its syntax and its subtleties, was dead to the many who used the vernacular, and to whose ears it brought no associated charms. On their minds it made an indirect impression. It was not translucent, but required translation. Yet from it our ancestors learned melody of rhythm, grace of form, and carefulness of collocation. Grammar and prosody were seen ruling within the verses of the Latin writers. When love, gaiety, war, home, and life made their hearts quiver and their spirits brisk, they could not brook the artistic artificiality of a tongue they required to learn. They found a readier expression for their emotional nature in the lively vital poetry of the *Trouvères*. They caught the fire and force of the affections, and made them glow in the clear bright light of sunny song; they seized the moments of intense life and gave them an eternal abiding in sweet verse; they realized in chronicle and romance the very spirit of history and experience, and made their events memorable for ever. In fabliaux and satire, they gave animation to the morals of life, the teachings of religion, and the requirements of politics. In the intellectual life of England's choicest spirits, the epic-like poetry of the *Trouvères* wrote itself, as it were, in sunlight. There were, first, the Charlemagne romances, then the "Chanson de Roland," a tale of the time (778)

"When Roland brave and Olivier,
And every paladin and peer
On Roncesvalles died."

It was written by Thorold, the tutor of the Conqueror. After these came "The Four Sons of Aymon" (Duke of Dordogne), reproduced by Huon de Villeneuve (1165–1223); "Roland and Ferrabras the Giant;" and "Ogier the Dane," a story of Holger or Olger, the national hero of Denmark. These poems were powerful on the minds of the Normans, and they communicated some of the enthusiasm of sword-fight and valiancy to the Saxon spirit. These metrical romances Britain, which was as yet unlearned in vernacular rhymes, could only match with imaginative prose fiction of similarly prevailing power.

The Arthurian legends of Geoffrey of Monmouth, vitalized by Mapes, and suggesting a family relationship subsisting of old times between the Brezonese and the Britons, wrought mightily on the congenial imaginations of the men of an age in

which the eucharistic mystery embodied their highest ideal of truth, peace, and righteousness. Robert Borron of Nottingham took Mapes' Latin "Historia de Gradali" (of the Graal) and gave it a new life in the vernacular French of his age and land; and drew from the obscure Latin of Nennius, the Celt, the story of Merlin the magician. Mapes wrote the "Quest of the Holy Graal," the "History of Lancelot of the Lake," and the "Death of King Arthur." He also created Sir Galahad, the ideal knight, son of Lancelot and Elaine. "Tristan" owes its first part to Luke de Gast, near Salisbury; and Hélié de Borron not only added a second part to this beautiful story, but composed besides "Gyon de Courtois, or Sir Palamedes." These were all written in French prose, but because they fired the fancy, excited the imagination, and roused the spirit of poetic creativeness—as they have done even until now, when the best minds see that these legends can be made the mirror of true manliness—they soon bloomed into verse, and had for their flowerage the metrical romances of "Chrétien de Troyes," "Percival of Wales," "Tristan" (lost) "Chevalier au Lion," the original of Ywaine and Gawain, "Eree and Enid," "Fregus" (whose hero is a Scotchman), the "Romance de la Charrette," and the "Romance de Cliges." Wolfram von Eschenbach carried the story into Germany, and made of the whole a parable of worldly life, in its joy, splendour, and self-satisfaction, set in contrast with an existence higher, spiritual, eternal.

The French had felt the touch of inspiration when they heard the singular story of Richard Cœur-de-Lion; and his adventurous career was instantly glorified in song. An English metrical version of this heroic poem, brought, in the time of Edward I., the heroism of their crusading sovereign under the magic of minstrelsy. The "Alexandreis," a conjoint work of Lambert li Cors and Alexandre de Bernay, made the monarch of Macedon familiar to men's minds, and gave to literature the *Alexandrine* line of twelve syllables.

We should fail to show the manner in which these romances won the heart and influenced the life of the Saxons under Norman sway did we leave unnoticed the "Roman de la Rose" begun by Guillaume de Loris, as a dream of love in search of beauty, and transformed by Jean de Meung as an allegory of man's quest for truth, the popularity and power of which was such that Chaucer employed his "prentice hand" in translating the fashionable French romance, and Froissart, in his early poetic pupilage, made it his model; Wace's "Roman de Rou" (Rollo the Ganger), in which he versified the "History of William Duke of Normandy," written by William ot Poictiers, the conqueror's chaplain, and tells the story of the conquest partly in Alexandrine, partly in octosyllabic metre; Geoffrey Gaimar's reproduction into Anglo-Norman verse of Geoffrey of Monmouth's "History," which was afterwards superseded by Wace's "Brut d'Angleterre," and was, in its turn, replaced in the early years of the thirteenth century, by Layamon's "Brut"—of which a second English translation appeared in the middle of the fourteenth century. These and other similar poems were imitated and reproduced in England, and thus they affected largely the subsequent literary labours of those who shaped and formed the language of the land.

Alfred of Beverley abridged Geoffrey's "Historia," and added to it abstracts of such other chronicles as he could borrow, closing it with an epitome of Turgot, who rose from being a clerk in Jarrow to be prior of Durham and bishop of St. Andrews, and wrote a "History of the Monastery of Durham," from which Alfred selected some well-told facts of which that writer had been an eye-witness. Gerald de Barri, called also Silvester and Cambrensis, born in Manorbeer, near Pembroke Castle, was an ecclesiastical reformer, wrote a "Topography of Ireland" and a "History of the Conquest of Hibernia," an autobiography, and a collection of letters, speeches, poems, and miscellaneous writings, as well as the "Gemma Ecclesiastica" (The Jewel of the Church).

Layamon's "Brut," to which we have already alluded, is a sort of history of England in unrhymed alliterative verse. It is in great measure a translation of a French work called "Brut d'Angleterre," by a learned Jersey-born monk, named Richard Wace, canon of Bayeux, in the time of Henry II. He had taken as his authority the chronicle of Geoffrey of Monmouth, the main part of which had been founded on old Welsh MSS. brought from Brittany, a Celtic-speaking part of France. Layamon, "a prieste of Ern eye uppon Severne," now known as Lower Arley, in Worcestershire, accepting Wace's verse as a groundwork, reproduced and expanded the matter it contained, and added, from other sources, such incidents and adventures as he could gain knowledge of for the instruction and entertainment of the laity of his native land. Wace wrote in rhyme; but Layamon, under the influence of the old Saxon poets, retained, except in a few instances, their alliterative measures, and, though his original was French, he scarcely ever employs a French word, unless it is impossible to find an English synonym. Though composed in its earlier form about 1204, there are not to be found in its 32,500 lines more than sixty words of French. In a later version (after 1250) several French words are introduced, many old words are replaced by more modern ones and in numerous cases substantives having their plural ending in the southern Saxon *en* in 1205 have, after 1250, been changed into the midland Saxon plural-form ending in *es*.

Layamon, following the old chronicles, relates that Brutus, great-grandson of Virgil's hero, Æneas, having gathered a band of Trojan kinsmen from among the exiles who had, after the siege of Troy, taken refuge in Greece, put himself at their head, and after many perils landed at Totness, on the banks of the Dart, in Devonshire. He became "father to a race of kings," among whom were Lud, Bladud, Lear, Gorboduc, Lucius, &c., the last-mentioned of whom is Cadwallader (689 A.D.). He dilates with great fulness on the exploits of Urther Pendragon, and of his famous son, "King Arthur, the Knight of the Round Table," *dunt Bretun dient mèint fable* (of whom the Britons tell many a fable). This first of the patriot singers of the new era did a work of note in widening the horizon of the imagination, in peopling the past with historic incident and personal prowess, and in arousing within the listeners to his lay the feeling of national interest in the events he recited. This, he indicates, was his purpose in writing—

"Hit com him in mode;	"It came to him in mind,
And on his mern thoake.	And in his chiefest thought,
Thaet he wolde of Engle;	That he would of Engle[land]
Tha Aethelan tellen.	The noblest actions tell.
Wat hes ihoten weoren;	What they were called,
And wonene hes comen	And whence they came,
Tha Englene londe	That the English land
Aerest ahten."	Earliest possessed."

To this historic poem there succeeded, ten years afterwards, the "Ormulum," Ormin's work on the Gospels, a series of homilies, in metre, yet without alliteration or rhyme, on the lessons of the day read at mass. It is never very poetical, often very practical, simple in expression, pleasant in style, and quite distinct in its didactic enforcement of the truths of Scripture. The Augustine friar had not only set himself to inform the minds of his readers, but to fix and settle the orthography and pronunciation of the language of his contemporaries. This imparts to his writings an air of greater rudeness and antiquity than they really possess; but he is rigorous in carrying his system into practice, and vigorous in insisting on its propriety as an aid to the proper delivery of what he has written.

At Kingston, formerly Keynestone, near Crayford Bridge, Dorset, Ralph de Kaines, a son of one of the followers of William the Norman, built and endowed a nunnery near his mansion of Tarente, for three pious ladies, and such lay-servants as they might need. Richard Poor, a native of Tarente, enlarged the convent, increased its income, and reconstituted it according to the rules of the Cistercian Order. As a directory for the fair anchorites who dwelt therein he, being then Bishop of Durham, composed in the vernacular of the west of England a work entitled the "Ancren Riwle" (the Anchoress's Rule). Therein he treats of (1) devotion; (2) the government of the senses in the keeping of the heart; (3) reasons for a conventual life, with lessons and exemplifications; (4) avoiding and resisting temptations; (5) confession; (6) penance and repentance; (7) Christian charity; and (8) duty in social and domestic life. It is of little value as

literature, but of considerable importance in tracing the progress of the language. Perhaps, owing to its subject, it contains a much larger infusion of French words than Layamon's "Brut," though it is decidedly semi-Saxon in transition towards Early English.

Political purposes, party strifes, court intrigues, missions and embassages, wars and rumours of wars, ecclesiastical plots and squabbles, luxurious living in high places and patient suffering among common people, contests of kings and barons, prelates and potentates, outcry of the lowly and oppression by the mighty, form by far too much of the staple of the history of our race. Inroads, invasions, onslaughts, and battles, evictions and seizures, sieges and sacks, riots, conspiracies, murders, and martyrdoms, constitute the perennial evidences of the effervescence of passion in man, and man's greed of possession. But the true growth of a nation is not made manifest in these. Arts, industry, home-life, church-going and feast-making, labour and holiday-life, May-game and tavern-song, ballad and hymn, field-sport and village-green play, tell us more of man and life than those noisy dissonances of national and ecclesiastical contentions and that many-voiced political strife with which the records of old times are filled. The manners and habits of men, their modes of life and thought, the growth and progress of humanity in them—these are the important and distinguishing matters in genuine nationality, and it is these which literature enshrines. Literature is life's thought recorded—is the register of life's power. When life glows with and glorifies itself by love it sings. The emotions quicken thought into expression, and thought receives "a life beyond life." In the dim cloister, in the lowly cottage, amid the grain-gifted fields, in the workshop, by the forge, and at the loom the under-songs of life are heard, and rhyme rings out, however rudely, the real emotions of the heart. In these the folk-speech of the time embalms the feeling of some supreme moment of life, and that which had made one spirit vocal becomes the accepted utterance of the simple laity whose experience it expresses. England has never been without its poetry of peasant life, its folk-songs, its home lays, and its holy lowly chants.

Of late years many rich discoveries have been made regarding the folk-literature of Early England. Numerous individual collectors have printed some of the best they had, and by associated effort many curious specimens of the popular poetry and prose of distant periods have been issued for the use of students of the progress of the land and the language. The Philological Society, the Early-English Text Society, and other kindred-minded labourers in literary investigations, have added vastly to the stores available for research and study. To them England owes an immense debt. It is matter for thankfulness that these recoveries from the wrecks of time are gradually being not only restored but stored, so as to be made, by able editorial care, available for the comprehension of the thought of the olden time in the highest expression it had, or at least in the best form in which we can now have it brought before us.

HISTORY.—CHAPTER II.

THE HISTORY OF THE CONSTITUTION OF ROME.

In the first period of the real history of Rome, which extends to the 363rd, or according to some, to the 387th year of the city, the first inquiry of interest which presents itself is its government. The early constitution of the city was monarchical. This period of its annals is mixed with legendary fable. No one has yet been able to winnow the few grains of truth from the immense heap of chaff. The earlier writers of Roman history have made matters worse. They build up the Roman constitution from simple elements according to their own fancy, and, taking the names of the few Roman kings preserved by tradition, they have attributed one part of the structure to one and another part to somebody else, in order to lend a semblance of probability to their own conjectures. All that we can do is to collect the scattered notices that have survived of the position of the city in different years within this period, and from them to infer the development of its constitution. The earlier history of the empire is that of a strictly constitutional municipality. But at length the city of Rome was the Roman state. The neighbouring states hemmed it in on all sides. Never had its domain extended very far from the city walls. At times victory enabled Rome to exercise a greater influence among the states in her neighbourhood than at others; but during the whole of this first period Rome proper was the city, and all her institutions sprang from the relations in which the citizens of this narrow space stood to one another.

The city means that space around which walls had been erected previous to the expulsion of the kings in the year of the city 244. Within this space, however, there were several burghs, each with its own fortifications and walls of defence. The Capitol was so fortified that it was successfully defended against the Gauls after these invaders had made themselves masters of the rest of the city. The Aventine, as we learn from an event which took place at the time of the secession of the plebeians to the Mons Sacer, on account of their oppression by the patricians, had its fortifications apart. While the rest of Rome was held during these civil dissensions by the patricians and their defendants, the Aventine was retained as a stronghold by the plebeians; and on several occasions, both previous and subsequent to the secession to the Sacred Mount, the plebeians regarded the Aventine as more especially their own quarter. The Palatine, too—the city more especially ascribed to Romulus—seems to have had its own separate defences. These facts suggest that each of the hills upon which the imperial city stood may have been originally the seat of an independent tribe.

Roma is not an Italian word; it is conjectured to have been the name of a Pelasgian settlement on the Palatine. The Quirinal appears to have been settled from the earliest times by the Sabines, an Ascan race. From the name of the inhabitants of this hill—Cures or Quires—comes the word Quirites, of frequent occurrence in Roman history as the formal designation, so long retained by the citizens, of *Populus Romanus et Quirites*. The descendants of these different races probably formed the two great original tribes of Rome, the *Ramnes* and the *Tities*. This union also, perhaps, gave rise to the idea of a deity peculiar to the Romans—"Two-headed Janus"—the opening and shutting of whose temple was indicative of war or peace, and the site of which was on the boundary line between the district of the Quirinal and the Palatine. Of a third tribe in old Rome, the Lucĕres, the origin cannot be so satisfactorily traced; but many circumstances lead us to attribute it to a Tuscan colony settled on the Cælian Mount. These three tribes are the oldest divisions of the Roman citizens of which any record has been preserved. Each had its own region. They were originally divided into thirty *curiæ*, and these into 300 *gentes*. Each tribe, therefore, consisted of 100 gentes, and constituted a *centuria*. They had the right of intermarriage, and from them the senate was filled.

The admission of other communities at a later date, when the union of these three had made them strong enough to prescribe terms, was granted upon less favourable conditions. This seems to have been the origin of the distinction into patricians and plebeians. The patrician was not necessarily a senator—he was only one capable of being admitted into the senate. The more recently admitted tribes found the government posts filled by the old tribes; and contented, in the first instance, with reception into the bosom of so powerful a state, made no claim to the privilege of holding them. Hence the distinction into patricians, who reserved for themselves the magisterial and priestly offices; and plebeians, arms-bearing freemen. Time augmented the number of the plebeians. Every person admitted to Roman citizenship swelled their ranks. Of this class were many who had themselves been noble in the states they belonged to by birth. While the plebeians were increasing in consequence and in number, and the ambition and intelligence of individuals among them grew, the germs of disunion rapidly developed among the patricians. The most powerful—through wealth, connections, and talent—naturally obtained important positions in the state. The possession of these in turn increased their strength. Office thus became in a manner hereditary in a family. The patricians came to be divided into the greater and less houses.

between them and Rome ; they were ambitious of extended rule ; and there are still sufficient traces left in Roman history to enable us to see that Rome was at one period hard pressed, if not indeed for a time entirely subdued, by the Etrurians. From the upper valleys of the Tiber and the Anio the rude Ascan tribes poured down upon her. Grecian invaders, from the north-east of Italy, were driving the aborigines across the summit of the Apennines, and as they came crowding over one shoal after another, those who were already settled there were driven downward towards Rome. Even from the kindred Latins came hostile assaults. Alba, in the infancy of Rome, had arrogated to itself supremacy over the other cities of the Latin confederacy, and deference and submission were exacted from the new-born city of Rome, which its inhabitants did not even then yield without a struggle. The men of Rome were exercised in war from the beginning. They were forced into battles, felt the excitement of strife and the rapture of conquest.

Often was Rome thus reduced to extremities. While the Pelasgic settlement, *Roma*, properly so called, or the Palatine, was the state, the Sabines pitched their tents within the walls. Shortly after the expulsion of the Tarquins, the sovereign of Etruria was master of the Janiculum. The Capitol alone held out, and had not the gabbling of some geese (says the legend) awakened a citizen, when the stealthy feet of the Gaul already pressed the top of that rock, Rome might have been a name nowhere in history.

At a very early period we find Rome acknowledged as head of the Latin confederate states. Polybius has preserved for us a treaty between Rome and Carthage, concluded in the year after the banishment of the Tarquins. We find in this document the whole line of coast from the mouth of the Tiber to Circeii called the Latin coast—the country itself Latium. Many of the cities in this range of territory are expressly enumerated as subject to Rome—Ardea, Antium, Aricia, Circeii, and Terracina. Rome stipulates directly for these as well as for herself. It is clear from the terms of the treaty that it was concluded with Rome as the sovereign of several Latin cities, and as at that time the most influential and responsible member of the Latin confederation.

The whole semicircular central district of Italy felt and owned her influence. At this period of her career she came into contact with the Gauls. About that time the Transalpine Celts were being driven down upon the valley of the Po. The Romans sent envoys to negotiate between the Gauls and some friendly Italian states. The Celts sought nothing better than a cause of quarrel with Rome. They got it from the indiscretion of one of the envoys. "Towards Rome!" was the cry, and the mass of living beings, like a locust-swarm, moved onward. The foremost threw themselves upon the enemy's arms ; and, thus entangling them, left their bearers defenceless against the blows of those who followed. The art of war was vain against such a crowd. Down every defile and mountain-pass converging to Rome, their myriads swarmed. Army after army was swept away, and the walls of Rome crumbled beneath their assault. The Capitol alone was the Roman state. But the stubborn pertinacity of the Romans proved an overmatch for this force. The invaders, wearied out by the protracted resistance of the Capitol, relinquished the attempt to take it, and dispersed in search of fresh booty. Once fairly scattered, Roman discipline quickly overmastered them.

As far as we can judge of them, the conquests of Rome were rather forced upon than sought by that city. The battlefield was a narrow one. There is a picturesque and individual interest attaching to the topography of the environs of Rome. Along every ravine, where mountain-streams fret along their channels, we find enduring monuments of these times—the colossal stones of the old ramparts, girdling isolated rocks, where Veii, Crustumenæ, or Corioli stood. In this mountain-pass the whole house of the Fabii perished ; that isolated height is most probably the castle which they held on the frontiers of the Roman territory—Rome itself not being five miles distant. Upon this parched and barren plain, Coriolanus bowed the stubborn knee, and exclaimed, "O mother, mother, you have saved your country, but lost your son!" Here is the mountain-lake on the banks of which the enthusiastic chivalry of Rome persuaded themselves that they saw Castor and Pollux, mounted on white horses, fighting at their head. In this secluded glen, where the deep noiseless water laves abrupt precipices perforated by myriads of sepulchral monuments, repose the bones of the citizens of Cære, within whose walls (B.C. 390) the most sacred objects of Rome found shelter and security, when the rude Gaul dabbled his hands in Roman blood. Soracte and Mount Algidus still gaze upon each other across the valley of the Tiber. The spectator, perched on either mountain, may see now, as in the days of old, the sunshine poured down o'er crag, and stream, and tree ; or the storm-drift urged, by the wind-eddies across its surface, in strange, shifting, vapoury forms. And here we can feel with them, when we read their history, as if they were living still.

The peculiar conformation of the city of Rome superseded, in a great measure, the necessity of colonies, swarming off from the present hive by means of the *ver sacrum*, or sacred spring. With a view, however, to keep in subjection conquered states, colonies were settled, not on fresh unbroken lands, but in already settled states. A conquered city was amerced in a portion of its lands. Parcels of these were disposed of, by lot, to such Roman citizens as were willing to settle, as a colony, among the new subjects. This body served to keep the vanquished from revolt; and their fidelity was assured by the ill-will naturally entertained by the old citizens to intruders, not merely upon their fields, but into their very fire-sides. Rome thus maintained, at no expense, garrisons carefully thrown out on every side, in such a manner as to be able to relieve each other, and thus secure themselves until succour was obtained from the city. Tribute was derived from these dependent states ; and contributions were exacted, under specious pretexts, from the independent cities of the Hernican and Latin confederacy, to which many cities of the old Etrurian league had acceded—the Roman garrisons scattered among them under the name of colonies affording guarantees for the regular payment of the demands. The reverse occasioned by the invasion of the Gauls interrupted this system of Roman rule over the central Latin states only for a moment, and was ultimately the occasion of accelerating its progress. The strength of Rome was shaken by the rude grapple of the Celts, but that of the other cities was utterly prostrated by it. They fell an easy prey to the recurring energies of Rome, and Rome had by this time contracted an insatiable appetite for conquest. Pride and avarice alike spurred it on. Victory and defeat had each contributed to increase its warlike skill. With a dogged and stubborn resolution the Romans set themselves to master all with whom they came in contact; and they persevered until they had brought to their feet a world infinitely wider than the most learned among them could have conjectured to exist when they undertook the task.

Rome eventually became sovereign of the whole of central Italy. This, however, was a position in which they could not remain stationary. The Romans found themselves within an enchanted circle, from every point in the circumference of which they were at the most unexpected moments liable to assault. They penetrated northward to the banks of the Po, never retiring without leaving colonies behind them. In the south they overcame the gallant Samnites in Lucania and Apulia, where they found new neighbours—the Grecian cities which had colonized, after the Greek fashion, all lower Italy. In the prosecution of their schemes of conquest over these states, the Romans required to measure their strength with a more formidable enemy than they had yet encountered. Tarentum, the most powerful of the cities of Magna Græcia, in the southern extremity of Italy, beheld the advance of the Romans with alarm. The Tarentines called Pyrrhus to their aid—the ambitious monarch who at that time swayed the sceptre of Epirus. The Romans, allured by the prospect of wealth and luxury, as they were rushing to the spoil, found their career arrested for a moment by the Macedonian phalanx, flanked and strengthened by all that was powerful and imposing in Asiatic warfare. Pyrrhus, who had obeyed the call of the Tarentines more for the purpose of serving himself than them, having twice or thrice measured his strength with the Romans, found that little was to be got in Italy except

hard fighting. His pride would not allow him to retire altogether from the war into which he had rushed, but he kept it up only for the sake of saving appearances. He committed the defence of Tarentum to one of his officers. Two years after his departure the Romans made themselves masters of the city, and thus completed the conquest of Italy south of the Po.

The names of the different civil and military offices, and the mode of their appointment, remained unchanged. Everything at Rome, however, was altered. A great change was produced in the government, and in the constitution of Roman society, by these conquests, though at first it did not appear. The whole of Italy now formed one state, of which the city of Rome was sovereign. The magistrates of Rome, elected by the citizens, were the executive government and the judges in last resort of all this state. The mass of its free inhabitants possessed no civil rights. The executive government and judges were noways responsible to them. They were elected by, they paid their court to, they acted for, the interests of a privileged few, the citizens of Rome. The unprivileged many were kept in obedience by the system of settling armed garrisons among them, under the name of colonies. The Roman colonists acted in the interests of the general body. Their only safety consisted in earning by their fidelity support from central Rome. The magistrates, nominally elected by the whole citizens, were, *de facto*, elected by those only who remained close residenters in the city. These consisted mainly of two classes—the very wealthy and powerful, kept at home by ambition and love of intrigue; and the very poor, who had not interest enough with the dispensers of employment even to obtain a desperate chance of mending their fortunes abroad. Such rude wealth as flowed in under the name of tributes, or of tokens of friendship from independent states, was used by the senators to influence the elections. The distinction between patrician and plebeian was growing obsolete, for many plebeian houses had risen to equality with the patricians. But these had lost all common interest with the mass of plebeians. All the intelligence and energy of the less wealthy of the plebeian rank being tempted abroad, only the indolent and less worthy were left at home. The permanent inhabitants of the city soon came to consist of a small knot of wealthy and ambitious intriguers and an idle and venal rabble dependent for the supply of its wants upon doles from the public treasury. As these sank in worth, the consciousness that their city was the metropolis of Italy—that they were its sovereigns trampling daily on the necks of what had once been sovereign and independent states—inflated them with pride. Their corruption was further increased by the conquest of Greek cities in the south of Italy. "In former times," says Florus, "the victorious generals of Rome exhibited in their triumphs herds of cattle, driven from the Sabines and Volsci, the empty cars of the Gauls, and the broken arms of the Samnites: but in that which was exhibited for the conquest of Tarentum, the procession was led by Thessalian and Macedonian captives, followed by carriages loaded with precious furniture, with pictures, statues, plate, and other ornaments of silver and gold." The acquisition of luxuries, however elegant, by a rude people, is always fatal. The Romans were not at that time capable of appreciating the refined taste and imagination which spoke out in the works of art they had appropriated. But they could taste the debauchery in which their former proprietors indulged, and appreciate the power of wealth to procure such coarse pleasures. The Romans learned the vices of wealth and luxury before they learned their refinement: they blended the coarse violence of the savage with the excessive indulgence of nations refined even to effeminacy—political corruption, private debauchery, overweening pride; and yet the vigour of the national character was not sapped. The young vigour of the Roman constitution bore it a while scatheless. So much of the old constitution was retained that the Roman people, as a body, was still regarded as the great army of the state. In emergencies—and they were of sufficiently frequent recurrence—all were liable to serve. The extent of the city's territories—the frequent revolts among her half-subdued subjects—the frequent wars, rendered necessary by encroachments on her extended frontier, forced her to keep permanent armies in the field, and these were ever-open schools of hardihood and skill. These field-forces became not merely the means of enforcing the payment of that tribute upon which the metropolis subsisted, but also of keeping that metropolis obedient to law. The rivalry of the great patrician and plebeian houses was sufficient to keep the rulers of the state from degeneracy. Only so long as other states felt the superiority of Roman genius was Roman ascendency secure. It was not mere superior skill in arms that could effect this. Rome was now the court of appeal from all the subject states. At Rome there was, they were taught, greater store of legal wisdom than among themselves. One great secret of Roman success was this constant ostentation of the virtue of justice. With all their faults they were the wisest, most just, and most energetic rulers of a state the world had then witnessed. The indestructibility of many of their laws and institutions, which have survived even Rome's long-lived empire, is a sufficient evidence of this. The elements of anarchy, however, which slumbered undeveloped in the state, soon disclosed themselves, as we shall see, with tremendous and ultimately fatal effect.

GEOGRAPHY.—CHAPTER III.

HISTORY OF GEOGRAPHICAL DISCOVERY (1700 B.C.—1500 A.D.)

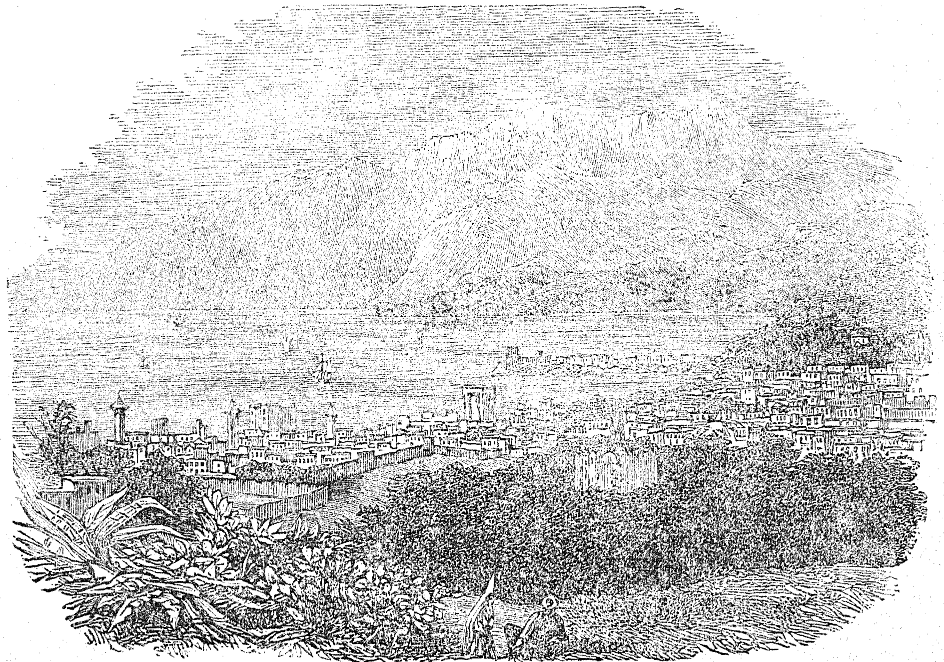
THE writings of Moses contain the earliest authentic information regarding the nations in the East with whom the Jews had any direct or indirect communication. He relates that, 1700 B.C., the Midianites, who inhabited the country between the rivers Euphrates and Indus, to the north of the Persian Gulf, carried on a traffic with the Egyptians, passing through Palestine. Of Asia Minor, Egypt, Arabia, Assyria, and Armenia in 500 B.C. the Jews certainly knew something; but Mount Caucasus on the north, Ethiopia on the south, the Archipelago on the west, and the river Euphrates on the east, constituted the utmost limits of their known world. They appear to have believed, in common with all the ancients, that the earth was a flat plain, and that their own individual nation occupied its centre; that it was immovable and fixed, and that the sun, moon, and stars performed their daily revolutions around it; that the extreme verge of this flat and circular plain terminated in a tremendous chaotic gulf of impenetrable darkness. It was the interest of the early explorers of unknown regions, who wished to monopolize trade and commerce, to originate and perpetuate such notions, and to magnify the dangers they had to encounter. The spirit of inquiry and curiosity was thus repressed, and the advantages of commercial intercourse were therefore long unknown.

The most enterprising people of antiquity of which we have any account were the Phœnicians. The country which they inhabited was a small, narrow, and mountainous, but exceedingly fertile district, extending along the eastern coast of the Mediterranean. The world of waters which rolled upon its shores invited them forth to live by enterprise and adventure. Their ships caught the breezes of the Levant. They scorned to hug the coasts of their neighbourhood, and tempted the ocean winds to visit and trade with the inhabitants of all lands. Their chief towns were Tyre and Sidon, Aradus, Acco (now St. Jean d'Acre), and Berytus (now Beyrout). When the Israelites took possession of the land of Canaan, Sidon was a "great" and Tyre a "strong city" (Josh. xix. 28, 29). Whether therefore the Phœnicians dwelt originally on the shores of the Red Sea or of the Persian Gulf, they must have settled on the coast of the Mediterranean at a very early period. Mount Lebanon supplied them with wood for shipbuilding; Sarepta (or Zarephath) afforded them iron and copper; and, upwards of 1000 years before the Christian era, they had navigated the whole of the Mediterranean, and founded the colonies of Hippo, Adrametum, Utica, Tunis, Carthage, and Gades (Cadiz). They traded with India by the caravans of Arabia and Babylon; and Herodotus, although he does not vouch for the accuracy of the statement, relates that they circumnavigated Africa, sailing down the Red Sea, and landing at Alexandria, after an absence of rather less than three years. The early Grecians 500 B.C.

were merely acquainted with the western part of Asia Minor, the sea-coast of Egypt and Libya, and a small portion of the south of Italy. In the fifth century B.C. the Grecians are said to have got possession of some Phœnician charts, to have extended their discoveries along the Mediterranean coasts, and to have founded colonies in Sicily, Sardinia, Corsica, and some of the southern provinces of Spain.

Herodotus (flourished 443 B.C.) may be styled the father of geography as well as of history. He travelled over the north of Africa, and traced the river Nile to 11° N. lat. In Asia he visited Tyre, Babylon, and in all probability Suza, and traversed the greater part of Asia Minor. In Europe he made a circuit through part of Southern Russia and the Greek colonies along the shores of the Black Sea. He traced the river Danube almost to its source, travelled through Greece, and reached the south of Italy. Herodotus never lost any opportunity, during his travels, of acquiring information regarding those countries which he was unable to explore. In this manner he was acquainted with a great part of Poland and European Russia, Western Tartary, the greater part of the countries on the river Indus, and Arabia. The countries which Herodotus visited in his manifold travels extended over 1700 miles from east to west, and 1660 from north to south; and the more the lands which he describes have been explored by modern investigators, the more thoroughly has his accuracy as an observer been established.

In his time the celebrated city of Carthage had reached its highest point of commercial prosperity. At an early date the Carthaginians took possession of Malta (then celebrated for its cloth manufactures), of Gozo and Lampedoza, and subsequently of the Balearic and Lipari islands, the former of which were then famous for the production of wine, oil, and fine wool, the latter for their delicious climate, warm springs, and rich fertility; they had settlements all along the northern coast of Africa, from Cyrene to the Pillars of Hercules, two rocks now occupied by Ceuta and Gibraltar. They had acquired the island of Sardinia by conquest B.C. 480, and some time afterwards they despatched two fleets to explore the western coasts of Africa and Europe. The first was commanded by Hanno, their king, and "consisted of sixty ships of fifty oars each, and a body of men and women, to the number of 30,000, with provisions and other necessaries." He passed the Straits of Gibraltar, near which he founded several cities; sailed round the west coast of Africa; discovered the Canary Islands and Madeira; and, having advanced as far south as Sierra Leone, was obliged to return



Beyrout and Mount Lebanon

for want of provisions. The second was led by Himilco. It sailed round the coast of Portugal as far as Œstrymnon Cape (supposed to be Cape Finisterre). The Carthaginians were acquainted with the northern provinces of Spain, and even with the British Islands, B.C. 400. They were not the first foreign nation that visited Britain. There is every reason to believe that the Phœnicians traded in tin with the inhabitants of Cornwall at a much earlier period. The power of the Carthaginians was first reduced by their military reverses in the attempts to take possession of Sicily, and finally destroyed, and Carthage razed to the ground, by the Romans, B.C. 146. Their colonies on the Straits of Gibraltar and elsewhere were then neglected and forgotten, and the key to their discoveries and extensive trade completely lost.

The illustrious Hippocrates, the father of medicine, flourished about 430 B.C. He prosecuted his researches in many countries, investigating the influence of different climates upon the human constitution. In his travels he almost followed the footsteps of Herodotus, and devoted so much attention to the natural aspects of the countries he visited as to be regarded as the founder of the science of physical geography.

About 340 B.C. Aristotle, the famous philosopher, directed his powerful mind to the study of this science. He collected all the information then extant on the subject; reduced it to a systematic form; deduced from the facts it supplied the spherical figure of the earth—the fundamental principle of geography; and having digested and arranged all its facts, he put them into the hands of his royal pupil, Alexander the Great, to enable him the better to concert his plans for the subjugation of the world. This mighty prince extended his conquests over Greece, Asia Minor, Palestine, Egypt, and Persia; and penetrated into India as far as the river Sutlej, the eastern branch of the Indus. Upon Alexander the instructions of Aristotle were not thrown away; he was imbued with a thorough zeal for the cultivation and advancement of the sciences, and he was scarcely less solicitous to leave a correct geographical account of his many expeditions than to extend the boundaries of his empire. The continent of Asia was opened up by the Macedonian monarch to the commercial intercourse of Egypt and Greece, and the effects of the career of Alexander were long felt among the nations of the East.

The Romans had reached no prominent position among surrounding nations up to this time, but in their intercourse and wars with the Carthaginians they learned the art of shipbuilding, and about 50 B.C. they had extended their conquests in every direction. The Roman generals vied with each other in transmitting to the capital descriptions of the different nations they subdued, so that, by the beginning of the Christian era, they were acquainted with all Europe south of the Baltic, including England, Scotland, Ireland, and the surrounding islands, the countries on the Danube, the Vistula, and the Volga, Africa as far south as the river Niger, and Asia as far east as the Ganges. In the reign of Augustus they discovered the monsoons, or periodical winds of Asia—a circumstance which contributed more than any other to the extension of their intercourse with Eastern nations. Instead of travelling across the desert from Syria to the Euphrates, sailing down the Persian Gulf, and along the northern coast of the Arabian Sea to the mouth of the Indus, they now adopted a much less hazardous, less expensive, and more expeditious route, by sailing down the Red Sea; and having passed the Straits of Babelmandeb, their ships were carried, by aid of the south-west monsoon, to the Indian peninsula between the Ganges and the Indus, and brought back again by the north-east monsoon in the course of the same year.

About A.D. 18, the accomplished Strabo finished the writing of his learned work on geography, the seventeen books of which, with the exception of book vii., of which we have only a slight epitome, have come down to us in a tolerably complete state. It gives a description of all the countries known to the Romans with surprising correctness and fidelity. Pliny, the naturalist, who died 79 A.D., and Claudius Ptolemy, the astronomer (flourished 150 A.D.), wrote excellent treatises on geography; but the known limits of the world were little if at all extended, and the spirit of commercial enterprise and discovery, which was fostered by the Roman conquests, declined amid the conflicts which resulted in the overthrow of their empire by the barbarians (476 A.D.)

Mohammed the prophet was born about a century later. In his zeal to propagate his religion over all the kingdoms of the earth, he gave the first fresh impulse to a revival of the long-suspended intercourse between different nations. Mohammed himself had no other end in view than the extension of his dominion over the world; but his successors, glutted with conquest, laid aside the art of war, and cultivated and encouraged the arts of peace. Under the sway of Harun-al-Rashid, literature and the arts were pursued with zeal and perseverance. This prince displayed a love of justice and of commercial enterprise. His reign was the golden age of the Mohammedan nations: flourishing towns sprang up in every part of his dominions; traffic by land and by sea increased, and Bagdad became the seat of the sciences as well as the mistress of the world. His son and successor, Al-Mamun, was still more celebrated as a patron of literature; his court was the resort of philosophers, mathematicians, physicians, and astronomers; all books and instruments serviceable for the promotion of science, which had escaped the ravages of barbarism, were collected for him from every quarter; colleges and libraries were founded in all the chief towns of his empire; geographical knowledge was cultivated; and in A.D. 833 this Abbaside prince obtained the measurement of a degree of latitude in the desert of Sangiar (plain of Shinar), to enable him to ascertain the magnitude of the earth.

The Arabians had by the middle of the ninth century entered into commercial relations with Madagascar, the Maldives, Ceylon, Sumatra, Java, and China. They had extended their conquests to Spain on the west, and to the river Ganges on the east; and wherever they carried their arms, their generals had orders to obtain correct information regarding every circumstance which might throw light on the geography of the countries they subdued.

The darkness which, after the subversion of the Roman Empire, overshadowed Europe, was first faintly illuminated by the professors of Christianity. By them the tides of ignorance and barbarism were stemmed; by them the arts and sciences were preserved, till, in the middle of the eighth century, the Mohammedan invaders of Spain came to their aid, and to a considerable degree helped in the diffusion of literature throughout Europe.

Alfred the Great, the illustrious and excellent Saxon king who reigned over England during the latter part of the ninth century, encouraged all kinds of learning and every useful art. He patronized travellers, and was the founder of that naval power which was one day to be the dread and admiration of the world. In his writings we have the earliest authentic account of Denmark, Norway, and Sweden. His information was based on the statements he received from some Normans who had penetrated these northern countries. About a century after his time, the Norwegians carried their researches as far as Greenland and the Shetland Isles, where the Danes founded colonies.

In A.D. 1001, a storm drove Biorn Hermessan, a Norman navigator, from Greenland to the coast of North America, or (according to some authorities) of Newfoundland. The intercourse of the northern nations with the American continent—which they called Vinland—exerted no influence on the progress of discovery, and cannot be regarded as lessening the real merit of the subsequent long-matured, carefully meditated, and boldly carried out victory for science gained by Columbus. Robert Southey's legendary epic (published in 1805) is founded on a statement in Caradog's "History of Cambria," that Madoc, the youngest son of Owain Gwynedd, king of North Wales, left his native country in 1170, sailed away to the west with a small fleet, and after a voyage of a few weeks reached America,

> "And stood triumphant on another world."

He founded a colony, and history affirms "that his posterity exist there to this day, on the southern branches of the Missouri, retaining their complexion, their language, and in some degree their arts." In Drayton's "Polyolbion" we are assured that

> "Madoc
> Put forth his well-rigged fleet, to seek him foreign ground,
> And sailed west so long until that world he found,
> . . . .
> Long ere Columbus lived."

These incidents are but the early streaks of dawn. The day which was to bring the red man and the white together had yet to come.

Towards the end of the eleventh century, the Crusades—wars undertaken by the Christians of the west to wrest Jerusalem and the Holy Land from the infidels—operated as a powerful means of advancing the civilization of Europe. By the intercourse which these Crusades occasioned between the eastern and western nations—by the transference of the estates of the nobility who were engaged in them into the hands of merchants—by the cultivation of the art of shipbuilding, for the purpose of transporting armies to Palestine—by the crusaders who returned home disseminating a knowledge of the useful arts which they had seen—and by the increase of trade and the acquisition of wealth in the maritime towns of Italy, political life received a powerful stimulus. The feudal system began to break up; commerce was aroused; agriculture and the useful arts were improved and extended among the nations of Europe; sciences and the fine arts were revived in Italy. However chimerical therefore the object of these holy wars may now seem—however deluded their promoters may appear to us, it is certain that nothing recorded in history exerted a greater influence in promoting the diffusion of knowledge, in extending trade and commerce, in extinguishing serfdom or slavery in Europe, and in advancing the civilization of mankind.

But these effects of the Crusades were not the only results which a desire for the promulgation of Christianity brought about; it also promoted a knowledge of distant countries, and extended the bounds of geographical discovery. Animated by the desire to Christianize the heathen, missionaries of the Christian religion undertook long and painful journeys during the eleventh, twelfth, and thirteenth centuries, through parts of Asia where European commerce had never penetrated, and where, particularly in the north of India, Tartary, China, and Japan, little is even yet known, except from the information which the accounts of these missionaries

afford. One of the most distinguished of these travellers was Marco Polo, a noble Venetian who in 1272 accompanied his father, uncle, and two Dominican monks as a missionary to the East. He and his companions were the first Europeans who visited China Proper. After spending nearly twenty-five years in traversing China, Tartary, Persia, and various other countries on the continent of Asia, visiting Borneo, Java, Sumatra, the Nicobar islands, Ceylon, Madagascar, and other islands in the Indian and Pacific Oceans, he returned to Italy, and arrived at Venice, with his father and uncle, in 1295. Having taken part in the war which was then raging between the Venetians and the Genoese, he was taken prisoner by the latter, carried captive to Genoa, and during the continuance of hostilities was detained in prison. While immured in this dungeon he wrote that narrative of his travels which continued so long to be the only source of information to Europeans on Oriental geography. It is much to be regretted that his misfortunes, after his return to his native land, prevented him from giving such detailed accounts of those countries as would no doubt have proved advantageous to science, and would have rendered him even more worthy than he is of bearing a title he well deserves—"the Humboldt of the thirteenth century."

That the mariner's compass was known in China, Japan, India, and Arabia from periods of high antiquity there can be little doubt; but to which of these nations the honour of the discovery ought to be justly awarded, will in all probability remain for ever a mystery. The compass was unknown to the ancient Greeks and Romans, as well as to all modern European nations, till a knowledge of it was acquired by the crusaders in the twelfth century, and promulgated through Europe on their return from the east. The compass was used for purposes of navigation on the coast of Syria long before this period, as we learn from a MS., written in 1242, by Bailak Kibdjaki, where he describes the method of magnetizing the needle. A little after the date of this manuscript it was generally known and partially used by European mariners; and having been greatly improved as a nautical instrument by Gioja, an Italian of Naples, about 1310, it soon became as indispensable to the seaman in guiding his bark through the trackless ocean, and in promoting geographical discovery, as the telescope is to the astronomer.

Few discoveries of any importance were made during the fourteenth century, but by the beginning of the fifteenth the art of navigation began to improve, and that spirit of hardy enterprise and bold discovery was awakened which was not again to slumber till every sea and ocean were traversed, and every portion of the habitable globe opened up to the mariner and explorer of Europe. The Portuguese were the first to attract the attention of the world by the fame of their maritime discoveries. Having rid themselves of their oppressors, the Moors, and carried their warfare into the enemy's country, they were soon afterwards led to round the west coast of Africa, which was then totally unknown beyond Cape Nun. In 1420 they discovered and took possession of Madeira; in 1433 Cape Nun was doubled for the first time; in 1445 they reached Senegal; in 1456, the Cape Verd Islands; in 1471–73, Prince's Island, St. Thomas, and Annobon; in 1484 they advanced to the mouth of the river Congo; and finally, in 1486, Bartholemy Diaz reached the southern point of Africa, which, without knowing it, he doubled in a storm, and called it the "Stormy Cape;" but for this King John II. of Portugal afterwards substituted the more pleasing name of the "Cape of Good Hope."

So noted did Portugal become under the influence of Prince Henry, the fourth son of King John I., as the great centre of attraction for the adventurous youth of other nations, that thither the bold and enterprising from all quarters flocked. Among others, the celebrated Christopher Columbus, a native of Genoa, in Italy, allured by the hope of employment as an explorer of unknown regions, came and settled in Lisbon about the year 1470.

Having a good education, and being distinguished for his proficiency in the sciences of geometry, geography, and astronomy, as they were then known, he entered upon a seafaring life at the early age of fourteen years. After some time spent on shipboard, cruising between various ports of the Mediterranean, he set sail for Iceland in 1467, on a voyage of discovery, which he extended 100 leagues beyond that island. On his return from these arctic seas, he settled in Lisbon, and married the daughter of one of those navigators who had been employed under Prince Henry in voyages of discovery on the coast of Africa. Having got possession of the papers, charts, journals, &c., of his father-in-law, and having found out from these that the object of the Portuguese researches to the south was to discover a route to India, the idea of finding a nearer passage, by sailing westward, took shape in his mind. By a train of reasoning based on the known sphericity of the earth, resting on the evidence of Marco Polo, which went to prove that the countries—China and Japan—which he had visited extended so far eastward as to approach Europe on the west, and relying on the facts that carved pieces of wood, trees of unknown species, and even two human bodies of a strange colour and unusual appearance, had all been discovered and picked up on the western coast of Madeira, Columbus was convinced of the moral certainty of the truth of his conjectures, and his mind burned with enthusiasm to prosecute his scheme of exploration and discovery, and to put his theories to the test of experiment.

But the sovereigns of Europe all stood aloof. He was looked upon as an idle dreamer and reckless adventurer; by some he was despised on account of his ignoble birth, by others, who fancied themselves learned, he was spurned because an obscure sailor had the audacity to anticipate the philosophical deductions which they ought to have made.

Columbus first applied to the Genoese; but they had the sagacity to foresee that if any other route than that hitherto followed down the Mediterranean should be discovered, the importance of their city as a commercial depot would be at an end. He then appealed to Portugal without success; and next, through his brother Bartholomew, made suit to Henry VII. of England, with the same unfortunate result. His means being exhausted in wandering from place to place, he was by this time reduced to poverty. During one of his wanderings a circumstance occurred which turned the tide of his fortunes, and led to the fulfilment of his hopes. While travelling through Andalusia, in Spain, he called at the convent of La Rabida to beg food for his child, and, an opportunity occurring, explained his views to the superior, Juan Perez Marchena. He was so struck with their grandeur and probability, that he warmly invited him to remain for some time at the convent, and ultimately gave him a letter of introduction to Fernando de Talavera, the confessor of Queen Isabella. Fernando pleaded the cause of Columbus so strongly, representing to his royal mistress that by acceding to the wishes of the navigator she would contribute vastly to the extension of the Christian faith, that Isabella agreed to aid his schemes on condition that Columbus should plant the *cross* on the first land he should discover. After many delays, Ferdinand and Isabella signed the stipulations, and Columbus at length set sail, with three vessels and 120 men, on Friday, the 3rd August, 1492.

After a tedious and anxious westward voyage, Columbus reached land on the 12th October; and filled with thankfulness and joy—kissing the earth—fulfilled his promise to the Queen of Spain by planting the cross in great solemnity, and naming the land San Salvador—now well known as one of the Bahama Islands. Columbus continued his voyage, and discovered several other of the West India Islands. After nearly suffering shipwreck on his homeward way, he landed at Palos, 15th March, 1493. He subsequently made three voyages across the Atlantic, and discovered a number of islands, as well as part of the coast of South America; but, although he mistook some parts of the land for Cipango (Japan), he failed of course to discover his anxiously sought-for passage to the East Indies. On the arrival of Columbus in Spain, after his last voyage in 1504, he found, to his inexpressible grief and disappointment, that his kind patroness, Queen Isabella, had died; and after suffering many mortifications from poverty and neglect, he died at Valladolid in 1506.

Columbus was not even awarded the honour of giving his name to the great continent he discovered. It was called *America*, after Amerigo Vespucci, a Florentine, who, in the

service, first of Spain, and afterwards of Portugal, made several voyages to, and discovered some parts of, the South American continent. Vespucci sailed from Cadiz, 20th May, 1499, as pilot to Admiral Hojeda, and in thirty-seven days had reached Cumana, explored the bay of Paria, and run along some hundreds of miles of the mainland coast of South America. In a second voyage, under Admiral Pinzon, he discovered those groups of islands which lie in crowds to the south of the Gulf of Mexico. In another, seeking a passage to Malacca, he suffered shipwreck, and found refuge in All Saints' Bay, on the Brazilian coast. After him came Juan de Grijalva, the surveyor of the shores of Mexico; Fernando Cortes, the victor of Mexico (1519) and the discoverer of California (1535); Francisco Pizarro, swineherd, soldier, explorer of the great middle plateau of the south, and conqueror of Peru (1532); Diego d'Almagro, colonist of Darien and pioneer of Spanish power in Chili (1535); and many other adventurers, greedy of wealth and athirst for excitement, who penetrated as far north on the west as the seaboard of Oregon and the mouth of the river Columbia.

THE FRENCH LANGUAGE.—CHAPTER III.

THE PARTS OF SPEECH—THE ARTICLE.

In French, as in English, there are nine different sorts of words, or, as they are technically called, parts of speech—article, noun, adjective, pronoun, verb, adverb, preposition, conjunction, and interjection. Of these the five first are inflected, the other four are unvaried.

The Article in French is employed to show the extent of the meaning of the noun before which it is placed. As it is a material help towards knowing the gender, number, and case of nouns, it is of great importance to learn thoroughly all its peculiarities, and to accustom the mind always to recall the proper article along with each noun.

Articles are of three kinds—(1) definite, (2) indefinite, and (3) partitive.

I. Definite Article.

Singular.			*Plural.*	
Masc.	*Fem.*	*Masc. & Fem.*	*Masc. & Fem.*	
le	la	l'	les	*the*
du	de la	de l'	des	*of* or *from the*
au	à la	à l'	aux	*to* or *for the*

II. Indefinite Article.

Masc.	*Fem.*	
un	une	*a* or *an*

III. Partitive Article.

Singular.			*Plural.*	
Masc.	*Fem.*	*Masc. & Fem.*	*Masc. & Fem.*	
du	de la	de l'	des	*some* or *any*

I. The definite article defines the exact extent of the meaning of the noun which it precedes. In the singular number it has separate forms for masculine and feminine, but in the plural it has only one form for both genders. When the article precedes a noun in the singular number beginning with a vowel or *h* mute (and *h* is usually mute in French), the third form of the article (*l'*, *de l'*, or *à l'*) is used, no matter whether the noun is masculine or feminine, the *e* of *le* being omitted and replaced by an apostrophe to simplify the pronunciation; as, *l'éclipse*, the eclipse; *de l'âme*, of the soul; *à l'homme*, to the man; but when *h* is aspirated the *e* is not omitted; as, *le houx*, the holly; *la haine*, (the) hatred (pronounce *le-oo*, *la-ayn*).

In the above table notice that *le*, the, joins with *de*, of, and *à*, to, and forms *du*, of the, and *au*, to the; but *la*, the feminine form of *the*, does not so contract in the singular number. Thus we must say *le village*, *du village*, *au village*, *les villages*, *des villages*, *aux villages;* but with a feminine word we must say *la ville*, *de la ville*, *à la ville*, although in the plural we say *les villes*, *des villes*, *aux villes;* while with a feminine word beginning with a vowel we say *l'école*, *de l'école*, *à l'école*, the plural being the same as with other words, *les écoles*, *des écoles*, *aux écoles*.

II. The indefinite article is *un* masculine and *une* feminine. It does not unite with *de* and *à*. It signifies a, any one in general, and has no plural; as, *un bijou*, a jewel; *une plume*, a pen.

III. The partitive article indicates that a portion or part alone of what the noun used implies is to be regarded as referred to; as, *Avez-vous des livres?* Have you any books? *J'ai de la fortune et des amis*, I have fortune and friends. It is in reality a compound of *de* and *le* employed idiomatically.

The following rules will provide ample guidance for the student in the proper use of all the French articles :—

1. The singular *definite* article, *le*, *la*, *l'* (before a vowel or *h* silent), and the plural article, *les*, signifying the, are used before (1) a common noun, taken either in a collective or an individual sense; as *Les hommes passent comme les fleurs*, Man passes (=fades away) like the flowers; *Les portes de l'église sont fermées*, The gates of the church are closed. (2) Names of materials and abstract nouns; as, *Le sel est la symbole de la sagesse*, Salt is the symbol of wisdom. (3) Names of countries, provinces, mountains, rivers, &c., except after *en* and (sometimes) *de;* as, *La France et l'Angleterre sont deux beaux pays*, France and England are two fine countries. But we must say, *La faïence fut faite d'abord en Italie*, Pottery was first made in Italy; *Robert ira de Flandres à Caen*, Robert will go from Flanders to Caen. (4) Names of dignities, titles, professions, &c.; as, *Les rois de France donnèrent l'Avignon aux papes*, The kings of France gave Avignon to the popes. When addressing dignitaries personally the article is left out; as, *Général*, *je demande votre pardon.* (5) Nouns following *Monsieur*, *Madame*, &c., when these words precede a name of dignity with emphasis either of honour or disgrace; as, *Monsieur le Capitaine faites votre devoir*, (Mr. the) Captain, do your duty. (6) Proper names used in a restrictive or peculiar sense; as, *La Rome de César*, *i.e.* Rome in Cæsar's time; *Le Dante*, *Le Napoléon.* (7) Verbs, adjectives, or other words used as nouns; as, *Le beau*, *le vrai*, *l'utile font les objets de notre admiration*, The beautiful, the true, the useful are the objects of our admiration.

2. The definite article is *repeated* before every noun (to which the foregoing rules apply) occurring in succession in the same sentence; as, *J'aime le père*, *la mère*, *et les enfants*, I like the father, mother, and children; *L'homme*, *la femme*, *et les animaux sont sujets aux maladies*, Men, women, and animals are subject to ailments.

3. The definite article is *omitted* before (1) names of towns (as a rule), but among the exceptions are *La Haye*, *Le Havre*, *Le Mans*, *La Rochelle*, &c.; (2) nouns so arranged as to form a climax, *Fortune*, *honneur*, *patrie*, *j'ai tout perdu*, Fortune, honour, native land, I have lost (them) all; (3) nouns used in proverbs or maxims, *Pierre qui roule n'amasse point de mousse*, A rolling stone gathers no moss; (4) nouns coming after *avec*, *comme*, *de*, *en*, *entre*, *jamais*, *ni*, *par*, *pour*, *sur*, *sans*, &c., when the meaning is vague; as *vol avec effraction*, burglary.

4. The *indefinite* article, *un*, *une*, is derived from the Latin numeral *unus*, *a*, *um*, one. In translating into French the English indefinite article, *a* or *an*, we must use (1) the French definite article, *le*, *la*, *les*, before nouns of number, weight, or quantity, when used in connection with price; as, *Ces plumes coûtent un franc* la *douzaine*, These pens cost one franc *a* dozen; (2) *par* before nouns of time; as, *Cents livres* par *an*, A hundred pounds *a* year. But the French indefinite article must be omitted before (1) nouns indicating trade, profession, title, or nationality, except when modified by an adjective or other sufficiently determinate noun; as, *Il est boulanger*, he is *a* baker; (2) titles of books; (3) *cent*, a hundred, *mille*, a thousand, and *demi*, a half; as, *Cinq mois et demi*, Five months and a half; (4) nouns in apposition which explain or particularize each other; as, *Le nommé Poiret*, *tailleur*, The man (called) Poiret, *a* tailor; (5) nouns preceded by *quel;* as, *quel homme!* what *a* man!

5. The *partitive* article (*du*, *de la*, *de l'*, *des*, some or any) is often understood in English without being expressed, *e.g.* He has bread and beer (*i.e. some* bread and beer); but it must always be expressed in French (1) before nouns used in a partitive or restricted sense, *i.e.* where the word *some* or *any* could be put before the noun without changing the meaning; as, *J'ai* du *pain*, I have (*some*) bread; *J'ai* de la *crème*, I have

(*some*) cream; *J'ai* des *bas bleus*, I have (*some*) blue stockings. (2) Before nouns in a negative interrogative sentence when the speaker really means to express a positive opinion; as, *N'avez-vous pas des livres?* Have you *no* books? (*i.e.* I think you have). (3) When a noun follows *bien*, *la plupart*, &c., as *Bien des persons*, Many persons; *Bien de la peine*, Much trouble; *La plupart des nations*, The majority of nations.

6. The preposition *de*, and not *du*, *de la*, or *des*, is used when

(1.) A partitive noun is the complement of a negative verb, as *Je n'ai pas d'amis*, I have no friends.

(2.) A partitive noun being the complement of an affirmative verb is preceded by an adjective; as *Il a de bons fruits*, He has some good fruits.

(3.) A partitive noun is used in a negative interrogative sense when the answer is not predetermined in the speaker's mind; as *Ne prenez-vous pas de pain?*

(4.) A noun follows a collective noun or an adverb of quantity; as *Vend-t-il beaucoup de taffetas?* Does he sell much sarcenet? *Nous voyons une foule d'hommes*, We see a crowd of men.

Exercise.—In the following examples of the use of the articles it will be advantageous not only to observe the special forms employed, but to look up the special rule which regulates each example.

Le palais *du* roi,	*the king's palace.*
La couronne *de la* reine,	*the queen's crown.*
Les jardins *du* duc,	*the duke's gardens.*
Les vertus *de la* comtesse,	*the countess's virtues.*
*L'*homme dont vous parliez,	*the man you were speaking of.*
*L'*aile *de l'*oiseau,	*the bird's wing*
Les amants *de* Pénélope,	*the suitors of Penelope.*
Les héroines *de l'*antiquité,	*the heroines of antiquity.*
Je l'ai donné *au* roi,	*I have given it to the king.*
Je les ai rendus *à la* princesse,	*I have restored them to the princess.*
*L'*ambition *des* hommes,	*the ambition of men.*
La beauté *des* femmes,	*the beauty of women.*
Donnez leurs enseignes *aux* régiments,	*give their colours to the regiments.*
Donnez leurs éventails *aux* dames,	*hand their fans to the ladies.*
Donnez-moi *du* bouillon,	*give me some broth.*
Donnez-moi *de la* sauce,	*give me some sauce.*
Donnez-lui *des* pommes de terre,	*give her some potatoes.*
Donnez-leur *des* légumes,	*give them some vegetables.*
Apportez-moi *un* tire-bouchon,	*fetch me a corkscrew.*
Prêtez-moi *une* brosse,	*lend me a brush.*
La grandeur *d'un* homme,	*the tallness of a man.*
La modestie *d'une* femme,	*the modesty of a woman.*
Il montra *une* fille *au* doigt,	*he pointed out a girl (with his finger).*
Me voilà *à l'*objet essentiel,	*I am come to the material point.*
Donnez-le *aux* femmes *aux* huitres,	*give it to the oyster-women.*
Venez ici, *la* laitière,	*come here, milk-woman.*
*L'*homme *au* beurre, j'ai besoin de vous,	*butter-man, I want you.*

CHAPTER IV.

NOUNS, PROPER AND COMMON—MODE OF FORMING PLURAL—EXERCISES.

A noun is the name by which a person, place, thing, or thought is indicated and recognized.

Nouns have two *numbers*, singular and plural; and two *genders*, masculine and feminine. There is no neuter gender in French.

Nouns are distinguished as *proper* and *common*. The former is a name applicable in the same special sense to one individual only, as Adam, Eve, Paris, La Seine, Les Alpes, *l'amitié*, friendship. The latter is a name applicable in the same general sense to any of many persons, things, or thoughts, as *l'homme*, man; *la femme*, woman; *la rivière*, river; *la montagne*, mountain. These may be the names of (1) real beings or things, as *le soleil*, the sun; *la table*, the table; *les chiens*, dogs; (2) imaginary ones, as *la nymphe*, the fairy; *la génie*, the genius; (3) collective, as *l'armée*, the army; *la foule*, the crowd; *le peuple;* (4) abstract, as *la sagesse*, wisdom; *la valeur*, courage; (5) compound, as *une arrière-pensée*, an afterthought; *un chef-d'œuvre*, a masterpiece; (6) derivatives, as *une plantage*, a plot of young trees, &c.; *plantation*, colony or settlement; *planteur*, planter; *plantoir*, a dibble (used in planting), &c., from *plant*, a young tree; (7) words or letters used as nouns, as *pourquoi*, why; *parceque*, because.

Proper nouns are used regarding one person only, and are therefore always singular, as *Corneille et Racine ont illustré la scène française*, Corneille and Racine have adorned the French theatre; unless when they designate (1) historic or renowned families, as *les Alexandres, les Césars, les Guises, les Bourbons; Les deux Corneilles sont nés à Rouen*, The two Corneilles were born in Rouen; (2) names of countries and places, *les Amériques, les Indes, les Alpes; La Seine a des Bourbons, le Tibre a des Césars*, The Seine has its Bourbons, the Tiber its Cæsars; (3) persons who resemble in power, nature, talent, &c., those whose names are used to denote them, as *Les Corneilles, les Racines sont rares*—Poets like Corneille and Racine are rare; (4) the titles of books, works of art, &c., as *Envoyez-moi deux Telémaques*, Send me two [copies of] Telemachus; *Tout le monde ne sait pas la valeur des Elzévirs et des Raphaels*, Everybody does not know the worth of [editions of] Elzévirs and [the paintings] of Raphael; *Nous avons acheté, en Espagne, deux magnifiques Murillos*, We have bought in Spain two splendid [paintings of] Murillo.

Common nouns may be used either in the singular or the plural. The singular denotes one of the kind named, the plural any number more than one.

MODE OF FORMING THE PLURAL.

The plural is indicated in general by the addition of *s* to the singular—*le père*, the father, *les pères*, the fathers; *la mère*, the mother, *les mères*, the mothers.

It is to be observed that these rules for the formation of the plural of nouns are more matters of orthography than of pronunciation, as the letters added are in general left unsounded, unless when carried over by *liaison*.

But (1) nouns whose singular end in *s*, or a letter including the sound of *s* (as *x* and *z*), remain unchanged in the plural—*le fils*, the son, *les fils*, the sons; *le héros*, the hero, *les héros*, the heroes; *la faux*, scythe, *les faux*, scythes; *la voix*, the voice, *les voix*, the voices; *le nez*, the nose, *les nez*, the noses; *le gaz*, gas, *les gaz*, gases.

(2) Nouns ending in the singular in *au*, *eau*, *eu*, and *œu* add *x* to form their plural—*étau*, vice, *étaux*, vices; *bateau*, boat, *bateaux*, boats; *feu*, fire, *feux*, fires; *vœu*, vow, *vœux*, vows; except *le landau* (a kind of carriage invented in Landau, a town in Bavaria), *les landaus*, and *bleu*, blue, *les bleus*, blues (speaking of differing shades).

(3) Though nouns in *ou* follow the general rule, as *clou*, nail, *clous*, nails; *sou*, *sous*, &c., yet the following seven add *x*:—*bijou*, jewel; *caillou*, flint or pebble; *chou*, cabbage or puff-paste; *genou*, knee; *hibou*, owl; *joujou*, toy or hobby, and *pou*, louse.

(4) Almost all nouns in *al* change these letters into *aux* for the plural—*cheval*, horse, *chevaux*, horses; *mal*, evil, *maux*; *tribunal*, tribunal, *tribunaux*, &c.; but (*a*) *aval*, surety; *bal*, ball; *cal*, hard skin, bunion, or corn; *carnaval*, carnival; *chacal*, jackal; *narval*, (a kind of) whale; *nopal*, (a plant); *pal*, stake or post; *régal*, feast, and some other little-used words follow the general rule and add *s;* (*b*) *archal*, wire; *bauchal*, a bow-legged man; *chenal*, channel, water-course; *sandal*, sandalwood, are not used in the plural.

(5) Nouns ending in *ail* form their plural in *s*, as *camail*, a short cloak with a hood (used for winter wear by the clergy), *camails; détail*, *détails;* but *ail*, garlic (except in botanical language, when it takes *ails*, or when *gousses d'ail*, cloves of garlic, is used instead); *bail*, lease; *corail*, coral; *émail*, enamel; *soupirail*, *vantail*, and *vitrail* take *aux*, *baux*, *coraux*, *soupiraux*, *vantaux*, and *vitraux: bétail* becomes *bestiaux*, cattle.

The gist of these rules may be briefly set before the mind in the following tabular form. French nouns ending in any non-sibilant letter generally form their plural from the singular thus—

Singular.	Plural.	Singular.	Plural.
	s	*as* plage	plages
au	aux	beau	beaux
eu	eux	jeu	jeux
ou	oux	chou	choux
al	aux	cheval	chevaux
ail	aux	travail	travaux

The words *aïeul, ciel, œil* have a double plural: thus, *aïeul* has its plural *aïeux* when designating ancestors, *la gloire de ses aïeux;* *aïeuls* when designating grandfathers (paternal and maternal), *il possède encore ses deux aïeuls.*

Ciel has its plural *ciels* for skies of pictures, bed-testers, ceiling of a stone quarry, and climate, *l'Italie est sous un des plus beaux ciels de l'Europe; cieux* in the sense of heaven, *le royaume des cieux.*

Œil has its plural *yeux* when signifying the sight; *œils* in other cases, *des œils-de-bœuf* (oval windows).

Travail takes *s* (1) when it signifies a machine for shoeing or grooming horses; and (2) when it is used for an official report furnished by statesmen. In all other cases it takes *aux; un universal* (in logic) makes *les universaux.*

Words of more than one syllable, ending in *ant* or *ent,* retain *t* final in the plural, though it is omitted by some authors; thus, *des enfants,* and not *des enfans.* The forty of the French Academy and the best modern grammarians concur in this.

The following nouns have no plural in French:—(1) the names of metals, taken in general, as *l'or,* gold; *l'argent,* silver; *le cuivre,* copper; *le plomb,* lead; *le fer,* iron. We do indeed sometimes say *les fers, les plombs,* &c., but then we consider these metals as wrought, and do not speak of them in the general mass.

(2) The names of habitual virtues and vices, such as *la foi,* faith; *l'espérance,* hope; *la charité,* charity; *la prudence,* prudence; *l'orgueil,* pride; *l'avarice,* covetousness; *la justice,* justice; *l'innocence,* innocence, &c.

(3) Infinitives and adjectives used as nouns, *e.g. le boire,* drinking; *le manger,* eating; *le beau,* the beautiful; *l'utile,* the useful; *le vrai,* the true, &c.

(4) The names of the sciences and arts, *e.g. l'agriculture, l'astronomie, la botanique, la chimie,* chemistry; *la peinture,* painting; *la rhétorique, la sculpture.*

(5) The following nouns have no singular in French:—

Les accordailles,	*espousals.*	Les entrailles,	*bowels.*
Les agrès,	*rigging.*	Les entrefaites,	*meanwhile.*
Les aguets,	*hiding-places.*	Les éphémérides,	*ephemerides.*
Les alentours,	*environs.*	Les épousailles,	*espousals.*
Les ambages,	*circumlocution.*	Les fastes (de l'histoire),	*calendars.*
Les ancêtres,	*ancestors.*	Les fiançailles,	*betrothing.*
Les annales,	*annals.*	Les fonts (baptismales),	*fonts.*
Les appas,	*charms.*	Les frais,	*expenses.*
Les archives,	*records.*	Les funérailles,	*funeral.*
Les armoiries,	*coat of arms.*	Les gens.	*people.*
Les arrérages,	*arrears.*	Les haubans,	*shrouds (of a ship).*
Les arrhes,	*pledges.*	Les jouchets,	*spills (for games).*
Les atours,	*elegant dress.*	Les lupercales (fêtes des),	*lupercalia*
Les besicles,	*spectacles.*	Les mânes,	*departed spirits.*
Les brisées,	*tracks.*	Les matériaux,	*materials.*
Les broussailles,	*briars.*	Les mœurs,	*manners, morals.*
Les calendes,	*calends.*	Les mouchettes,	*snuffers.*
Les catacombes,	*catacombs.*	Les munitions,	*ammunition.*
Les cisailles,	*clippings.*	Les obsèques,	*obsequies.*
Les ciseaux,	*scissors.*	Les pincettes,	*tweezers.*
Les complies,	*evening prayers.*	Les pleurs,	*tears.*
Les confins,	*the confines.*	Les prémices,	*first-fruits.*
Les décombres,	*rubbish.*	Les proches,	*relations.*
Les dépens,	*cost.*	Les représailles,	*reprisals.*
Les doléances,	*complaints.*	Les ténèbres,	*darkness.*
Les écrouelles,	*the king's evil.*	Les vivres,	*victuals.*
Les entraves,	*shackles.*	Les vêpres,	*vespers.*

There are in French, as in English, a number of nouns which have a meaning differing in the plural from that which they have in the singular.

The following are some of the most common. The plural is not, however, always limited to the special meaning here given, but may be used simply as a plural of the singular noun, and retain the meaning of it:—

Singular.	Plural.
Aboi, *barking.*	Abois, *death-agony.*
Arrêt, *sentence, seizure.*	Arrêts, *arrest (military).*
Assise, *course (in building), layer.*	Assises, *assizes.*
Chausse, *hood (academic).*	Chausses, *breeches.*
Ciseau, *chisel.*	Ciseaux, *scissors.*
Effet, *effect, result.*	Effets, *effects, goods.*
État, *state (in all senses).*	États, *estates (Parliament).*
Etre, *being.*	Etres, *parts of a house.*
Fer, *iron.*	Fers, *fetters.*
Gage, *pledge.*	Gages, *wages.*
Harde, *herd, leash.*	Hardes, *clothes.*
Lettre, *letter (in all senses).*	Lettres, *literature.*
Limbe, *limb (of the moon).*	Limbes, *limbo, outskirts of hell.*
Lumière, *light.*	Lumières, *knowledge.*
Lunette, *telescope.*	Lunettes, *spectacles.*
Manière, *manner.*	Manières, *manners.*
Trousse, *bundle.*	Trousses, *breeches.*
Troupe, *troop.*	Troupes, *troops, soldiers.*
Vacance, *period during which anything is vacant.*	Vacances, *holidays.*

The formation of the plurals of compound nouns is regulated by (1) the nature of the words compounded, and (2) the sense in which they are taken when so compounded, in which case the meaning guides us to the proper method of indicating the plural.

Compound nouns are most frequently formed in the following eight ways, viz.:—

1. By the union of two other nouns, in which case both take the plural ending.

Un beau-père,	*father-in-law,*	Les beaux-pères.
Un chien-loup,	*wolf-dog,*	Les chiens-loups.
Un chou-fleur,	*cauliflower,*	Les choux-fleurs.
Un fourmi-lion,	*earwig,*	Les fourmis-lions.

But *chèvre-feuille,* honeysuckle, makes *chèvre-feuilles; havre-sac,* knapsack, *havre-sacs, hotel-dieu,* hospital, *hotels-dieu.*

2. By joining an adjective to a noun, when both receive the plural augment.

Un basse-cour,	*poultry-yard,*	Les basses-cours.
Un grand-père,	*grandfather,*	Les grands-pères.
Un procès-verbal,	*prosecution,*	Les procès-verbals.

But *grand'-mère,* grandmother, makes *grand'-mères;* and *grand'-messe,* high mass, *grand'-messes.*

3. By uniting two nouns with a preposition, when the first alone is pluralized.

Un arc-en-ciel,	*rainbow,*	Les arcs-en-ciel.
Un basse-de-viole,	*violoncello,*	Les basses-de-viole.
Une canne-à-épée,	*swordstick,*	Les cannes-à-épée.
Un chef-d'œuvre,	*masterpiece,*	Les chefs-d'œuvre.

4. By placing a preposition before a noun, in which case the noun takes the plural ending.

Un contre-ruse,	*counterplot,*	Les contre-ruses.

5. By uniting a verb and a noun, *Réveille-matin,* alarm.

6. By prefixing an adverb to a noun, in which case the latter takes the plural—*Arrière-garde,* rearguard, *arrière-gardes.*

7. By conjoining a verb and an adverb, when no change is made in the plural—*Passe-partout,* skeleton key or keys.

8. By conjoining two adjectives, when each may be pluralized—*Une douce-amère,* bitter sweet.

Though the Academy has decreed otherwise, every page of modern French literature contains nouns derived from dead or foreign languages, which become by long and frequent use naturalized, and these are pronounced and form their plurals as if they were indigenous terms. Hence such words as the following take their plurals thus—

Singular.	Plural.	Singular.	Plural.
Un accessit,	des accessits.	Un déficit,	des déficits.
Un agenda,	des agendas.	Un diorama,	des dioramas.
Un album,	des albums.	Un domino,	des dominos.
Un alguazil,	des alguazils.	Un duo,	des duos.
Un alinéa,	des alinéas.	Un duplicata,	des duplicatas.
Un alto,	des altos.	Un écho,	des échos.
Un aparté,	des apartés.	Un embargo,	des embargos.
Un aviso,	des avisos.	Un errata,	des erratas.
Un bey,	des beys.	Un examen,	des examens.
Un bifteck,	des biftecks.	Un exéat,	des exéats.
Un bravo,	des bravos.	Un fandango,	des fandangos.
Un concerto,	des concertos.	Un folio,	des folios.
Un concetti,	des concettis.	Un forum,	des forums.
Un débet,	des débets.	Un frater,	des fraters.

Singular.	Plural.	Singular.	Plural.
Un hidalgo,	des hidalgos.	Un quatuor,	des quatuors.
Un imbroglio,	des imbroglios.	Un quidam,	des quidams.
Un impromptu,	des impromptus,	Un quiproquo,	des quiproquos.
Une lady,	des ladys.	Un quolibet,	des quolibets.
Un lavabo,	des lavabos.	Un récépissé,	des récépissés.
Un lazzi,	des lazzis.	Un recto,	des rectos.
Un lord,	des lords.	Un reliquat,	des reliquats.
Un lumbago,	des lumbagos.	Un satisfécit,	des satisfécits.
Un macaroni,	des macaronis.	Un solo,	des solos.
Un magister,	des magisters.	Un spécimen,	des spécimens.
Un maximum,	des maximums.	Un tibia,	des tibias.
Un mémento,	des mémentos.	Un tilbury,	des tilburys.
Un mémorandum,	mémorandums.	Un tory,	des torys.
Un muséum,	des muséums.	Un trio,	des trios.
Un numéro,	des numéros.	Un ultimatum,	des ultimatums.
Un opéra,	des opéras.	Un verso,	des versos.
Un oratorio,	des oratorios.	Un vertigo,	des vertigos.
Un palladium,	des palladiums.	Une villa,	des villas.
Un panorama,	des panoramas.	Une virago,	des viragos.
Un pensum,	des pensums.	Un visa,	des visas.
Un piano,	des pianos.	Un vivat,	des vivats.
Un placet,	des placets.	Un zéro,	des zéros.

When such words (1) are not in common use, or (2) have acquired a specific place as technical terms in the sciences or the arts, they retain their classical or foreign form; thus the French write, without *s*, *exequatur*, *veto*, *criterium*, and use *le maximum*, *les maxima; le minimum*, *les minima*, &c. They also preserve in the plural the foreign forms of such words as—

Singular.	Plural.	Singular.	Plural.
Un aviso,	les avisi,	Un lazzarone,	les lazzaroni.
Un carbonaro,	les carbonari.	Un libretto,	les libretti.
Un cicerone,	les ciceroni.	Un quintette,	les quintetti.
Un dilettante,	les dilettanti.	Un soprano,	les soprani.

EXERCISE I.

Write out the plural of the following nouns, indicating in red the change made:—*Agneau*, lamb; *aïeul*, ancestor; *ami*, friend; *amiral*, admiral; *animal*, animal; *arsenal*, arsenal; *armée*, army; *attirail*, implements; *aveu*, confession; *avis*, advice; *bal*, ball; *bibliothèque*, library; *blé*, wheat; *caillou*, flint; *canal*, canal; *caporal*, corporal; *chapeau*, hat; *cheveu*, hair; *choix*, choice; *ciel*, heaven; *cœur*, heart; *commis*, clerk; *cou*, neck; *corail*, coral; *cour*, court; *couteau*, knife; *cristal*, crystal; *croix*, cross; *débat*, debate; *diamant*, diamond; *doute*, doubt; *élément*, element; *élève*, pupil; *émail*, enamel; *enfant*, child; *épicier*, grocer; *éventail*, fan; *femme*, woman or wife; *fille*, girl or daughter; *fois*, time; *fou*, fool; *gant*, glove; *général*, general; *gentilhomme*, gentleman; *gouvernail*, helm; *héritier*, heir; *homme*, man; *honneur*, honour; *hôpital*, hospital; *in-folio*, folio; *joujou*, toy; *joyau*, jewel; *licou*, halter; *lieu*, place; *livre*, book; *madrigal*, madrigal; *maison*, house; *mal*, evil; *maréchal*, marshal; *mer*, sea; *mère*, mother; *moineau*, sparrow; *mois*, month; *monsieur*, sir, gentleman; *neveu*, nephew; *nez*, nose; *œil*, eye; *oiseau*, bird; *opéra*, opera; *palais*, palace; *papier*, paper; *perdrix*, partridge; *père*, father; *piédestal*, pedestal; *pois*, pea; *poitrail*, the breast of a horse; *portail*, church-gate; *pupille*, ward; *régal*, treat; *rival*, rival; *roseau*, reed; *sentiment*, feeling; *sérail*, seraglio; *serment*, oath; *signal*, signal; *sou*, penny; *soupirail*, air-hole; *travail*, work; *tribu*, tribe; *tribunal*, tribunal; *tribut*, tribute; *trou*, hole; *tuteur*, guardian; *vassal*, vassal; *ver*, worm; *vers*, verse, line; *vertu*, virtue; *vieillard*, old man; *villageois*, countryman; *voisin*, neighbour.

EXERCISES IN THE READING OF FRENCH.

The following sentences will, we believe, be found to contain in them every case which can arise in the pronunciation of French, and therefore condenses into the smallest possible compass a complete series of exercises, by the constant perusal of which a practical power over French pronunciation may be acquired. The student is recommended (1) to go over each phrase carefully, with the instructions given in Chapter II. before him, marking any special point over the words or phrases as they occur—*e.g.* (*a*) tick off the silent letters, (*b*) indicate the liaisons, (*c*) place above the vowels the key-sounds, and (*d*) above any consonant which takes an exceptional pronunciation; (2) to commit the French sentences to memory, and learn to repeat them as tests, references, and examples for similar collocations. It is often advantageous to copy out such sentences, and to repeat them from memory, using the copy for indicating, in *red* ink, any special slip in pronunciation made.

1. Nous fûmes au spectacle hier au soir. 2. Ma grand'-mère et mon oncle y furent aussi. 3. Pendant qu'on jouait une scène infiniment touchante, la femme de Monsieur Noël fit un si grand éclat de rire que j'en eus honte. 4. Qu'est ce que c'est que Monsieur Fabre? Il est bonnetier. 5. Il faut que l'âme soit immortelle. 6. La mort courait de rang en rang. 7. Le vent souffle du sud-est. 8. Nos mœurs mettent le prix à nos richesses. 9. Ah, mon fils malheureux! peut-être qu'il est maintenant enseveli dans les profonds abîmes de la mer. 10. Madame Brun est une femme abstraite. 11. Adam et Eve furent nos premiers parents. 12. Il est absurde et impossible de le faire. 13. Cela n'en est pas le sens. 14. Il y arriva avec quatre de ses gens. 15. La fièvre jaune les saisit, et ils moururent tous. 16. Il a différé son voyage jusqu'à la mi-août. 17. Je connais un des premiers officiers du roi. 18. Il devint extrêmement obscur, et le passage était long et étroit. 19. Quand il entendit le nom de son père, il se mit à pleurer. 20. Il a si grand appétit qu'on ne peut le rassasier. 21. Il est soûl de perdrix. 22. J'ai grand' soif. 23. Il était sur un trône d'ivoire. 24. Vos habits sont mouillés. 25. Que dirai-je? Parlerai-je ou non? 26. Parlé-je bien Français? 27. Ai-je encore des amis? N'aurai-je pas de confiance en eux? 28. Dussé-je y périr, j'irai. 29. Ne me suis-je pas blessé? 30. L'homme avait un air bénin. 31. Ces paroles bénignes lui plaisaient. 32. Connaissez-vous le curé de la paroisse? 33. Il croyait sentir en lui quelque chose de divin. 34. Ces paroles divines firent renaître la joie dans son cœur. 35. La sculpture donne de l'âme au marbre. 36. Je l'aime bien. 37. C'était un jour solennel. 38. J'ai acheté dix chevaux. 39. J'ai dix oiseaux. 40. Il y en a dix. 41. J'ai acheté sept pommes. 42. Il n'y en a que six. 43. J'ai pris six alouettes. 44. Tenez, voilà six sous. 45. J'y suis allé neuf fois. 46. Venez à neuf heures. 47. Il porte des habits neufs. 48. Ne concevez pas de soupçons contre lui. 49. Il a soustrait ce qu'il y avait de meilleur dans le logis. 50. Le sous-pied est rompu. 51. Je n'en puis plus.

TRANSLATION.

1. We were at the play yesterday (at) evening. 2. My grandmother and my uncle were there also. 3. While they played a scene peculiarly pathetic the wife of Mr. Noël raised a shout of laughter so great that I had shame—*i.e.* felt ashamed of it. 4. What is it that Mr. Fabre is? He is a capmaker. 5. It is necessary that the soul should be immortal (the soul must be immortal). 6. Death ran from rank to rank. 7. The wind blows from the south-east. 8. Our morals put the price upon our wealth. 9. Ah, my unfortunate son! perhaps (that) he is now buried in the profound depths of the sea. 10. Madame Brown is an absent-minded woman. 11. Adam and Eve were our first parents. 12. It is absurd and impossible to do so. 13. That is not the meaning of it. 14. He arrived (there) with four of his servants. 15. The yellow fever seized them and they all died. 16. He has put off his journey till mid-August. 17. I know one of the first officers of the king. 18. It became exceedingly dark, and the passage was long and narrow. 19. When he heard the name of his father he began to weep. 20. He has so great an appetite that one cannot satisfy it. 21. He is satiated with partridge. 22. I am very thirsty (I have great thirst). 23. He was upon a throne of ivory. 24. Your clothes are wet. 25. What shall I say? Shall I speak or not? 26. Do I speak French well? 27. Have I still friends? Shall I not have confidence in them? 28. Although I (ought I to) perish there, I will go! 29. Have I not wounded myself? 30. The man had a kindly appearance. 31. These kindly words gratified him. 32. Do you know the clergyman of the parish? 33. He believed he felt something divine in himself. 34. These divine words made joy arise again (to be reborn) in his heart. 35. Sculpture gives soul to marble. 36. I love him (it) well. 37. It was a solemn day. 38. I have bought ten horses. 39. I have ten birds. 40. There are ten of them.

41. I have bought seven apples. 42. There are only six of them. 43. I have caught six larks. 44. Stay ! there are six under. 45. I have gone there nine times. 46. Come at nine o'clock. 47. He wears new clothes. 48. Do not imagine suspicions against him. 49. He has taken away what was best in the house. 50. The gaiter-strap (under-foot) is broken. 51. I can do no more.

NATURAL PHILOSOPHY.—CHAPTER IV.

SECOND AND THIRD LAWS OF MOTION—COMPOSITION AND RESOLUTION OF FORCES—PARALLELOGRAM OF FORCES—EQUALITY OF MOMENTS—PARALLEL FORCES.

THE second law of motion is—*The change or alteration of motion, by any external force, is always proportional to that force, and in the direction of the right (straight) line in which it acts.* The word *motion* is used here as the equivalent of what has been defined as *momentum*, in which the quantity of matter moved is taken into account as well as the rate at which it travels. For example, there would be the same change of motion whether the velocity of 6 lbs. was changed 1 foot a second, or the velocity of 1 pound 6 feet a second. The change of momentum would be six in either case.

This second law, stated in terms of *momentum*, is—*The momentum or quantity of motion generated by a single impulse, or any momentary force, is as the generating force* —that is, m as f, when m denotes the momentum and f the force. Every effect is proportional to its cause; therefore a double force will impress a double quantity of motion, a triple force a triple motion, and so on. *Impressed force* is used here for impulse, in which the *time* the force acts is taken into account as well as the *intensity* of the force. Thus the impulse or impressed force would be the same whether a force of a poundal were acting six seconds or a force of six poundals were acting one second; in either case the impulse or impressed force would be six. When an unbalanced external force acts upon a body it changes the velocity of the body in the direction in which it acts, and the acceleration produced in a given time is precisely the same whether the body is at first at rest or in motion, or whether the force is acting alone or with other forces. When the acceleration is opposed to the original motion of a body it is called *retardation.*

The *momenta* or quantities of motion in moving bodies are in the compound ratio of the masses and velocities. The motion of any body being made up of the motion of all its parts, if the velocities be equal the momenta will be as the masses; a double mass will strike with a double force, a triple mass with a triple force, and so on. Therefore the motive force is as the velocity; and as the impulse is as the force which produces it, the momentum is as the velocity when the mass is the same; and as the momentum is as the mass when the velocity is the same, when neither are the same the momentum is in the compound ratio of both the mass and velocity—that is, m as bv, when b represents the body or quantity of matter to be moved, and v the uniform velocity generated in b.

Again, the spaces described by bodies in uniform motion are in the compound ratio of the velocities and the times of their description. In uniform motion the greater the velocity the greater is the space described in any given time; therefore the space is as the velocity when the times are equal, and when the velocity is the same the space will be as the time—that is, in a double time a double space will be described, in a triple time a triple space. Consequently the space is in the compound ratio of the velocity and the time of description—that is, s as tv, when s represents the space described by the body b, and t the time describing the space s, with the velocity v.

From these three general proportions—f as m (force is as momentum), m as bv (momentum as the product of velocity and mass), and s as tv (space described as product of time and velocity)—the general relations of these six quantities in uniform motion and impulsive or percussive forces are obtained, and all questions relating to uniform motions and the effects of momentary or impulsive forces may be resolved. These general relations are—

$$f \text{ as } m \text{ as } bv \text{ as } \frac{bs}{t}$$
$$m \text{ as } f \text{ as } bv \text{ as } \frac{bs}{t}$$
$$b \text{ as } \frac{f}{v} \text{ as } \frac{m}{v} \text{ as } \frac{ft}{s} \text{ as } \frac{mt}{s}$$
$$s \text{ as } tv \text{ as } \frac{ft}{b} \text{ as } \frac{tm}{b}$$
$$v \text{ as } \frac{s}{t} \text{ as } \frac{f}{b} \text{ as } \frac{m}{b}$$
$$t \text{ as } \frac{s}{v} \text{ as } \frac{bs}{f} \text{ as } \frac{bs}{m}$$

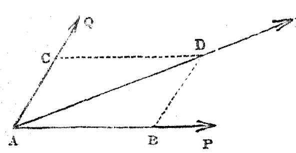
The path that a body will take when acted upon by two forces at the same time may be found by drawing a parallelogram, the two contiguous sides of which represent the two forces acting upon the body. The one side will be the path the body would have taken had it been acted on by that force alone, and the other side would be the path it would have taken had it been acted on by the other force alone. The diagonal of the parallelogram will therefore represent the path taken by the body when acted upon by the two forces together. This is called *the parallelogram of motion.*

The third law of motion is—*That action and reaction between any two bodies are equal and contrary;* that is, by action and reaction equal changes of motion are produced in bodies acting on each other, and these changes are directed towards opposite or contrary parts; or, in other words, action and reaction are equal and opposite. When the hand is pressed against a wall the pressure is resisted by the wall, and the reaction exerted by the wall is equal and opposite to the pressure of the hand; in this instance the action and reaction are both *pressures*, and without motion. The recoil of a cannon, when the ball is fired, exhibits a quantity of motion exactly equal to that of the ball, and this recoil is a force capable of performing work; in the instance of the Moncrieff gun-carriage it has been utilized for the mechanical self-adjustment of the gun after discharge. In this instance the reaction is equivalent to *quantity of motion*, exactly equal and opposite to the action. Thus the words *action* and *reaction* are the equivalent to *energy;* and the third law of motion therefore expresses in a few words the great principle of the indestructibility of energy. Motion is not destroyed by friction; the movement of the mass is replaced by the motion of the individual molecules. Neither is energy destroyed by impact or otherwise; for whenever motion ceases, whether it be apparent and that of the mass, or insensible and that of the molecules, new positions are taken up, and potential energy supplies the place of energy of motion, and there can be no destruction of the source of energy whatever. This is the principle of the conservation of energy. As potential energy disappears *kinetic* energy, or the energy of motion, comes into operation, and the sum of these energies is constant throughout the universe. It is as impossible to create or destroy energy as it is impossible to create or destroy matter.

The equilibrium of a body necessarily implies that it is acted upon by more than one force at the same moment of time. The simplest state of equilibrium is when the body is acted upon by two forces of equal magnitude in opposite directions on one point; thus the three elements of direction, magnitude, and point of application of the forces are in their simplest relation. These elements, however, may be variously combined in various systems of forces in equilibrium; the conditions of equilibrium will, however, be determined by the application of the fundamental law of the parallelogram of forces, by which the combination of several forces into one resultant is termed the *composition of forces*, and the decomposition of one force into two or more components the *resolution of forces.* Of the great variety of cases that occur in the composition of forces, that in which two forces act upon

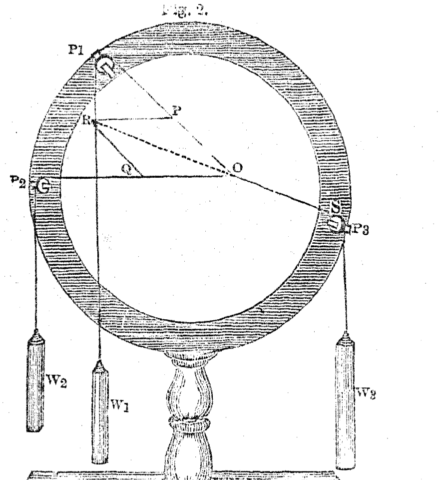
a point in different directions is the most important. The two unequal forces A P and A Q (fig. 1) act upon the point A in the directions of the arrows A P and A Q, and with magnitudes expressed by A B and A C. Their resultant, or the single effect of their joint action, will be expressed both in direction and magnitude by the diagonal of a parallelogram, of which A B, A C are the sides.

Fig. 1.



Draw C D, B D parallel to A B, A C respectively, and draw the diagonal A D; then A D, acting on the point A, is their resultant. This law is termed the *parallelogram of forces;* it is the foundation of all statical investigations, and is deduced from Newton's laws of motion; that is, by the first law it is force alone which can produce a change of motion in a body, and by the second law the change of motion is proportional to the mass of the body multiplied into the force employed, and takes place in the direction in which the force acts. Therefore when two forces act at the same instant in different directions on a body, each force impresses upon it the exact change of velocity which it would have produced had it acted singly upon the body when at rest, and each force is proportional to the change of velocity which it produces. This principle may be proved experimentally by

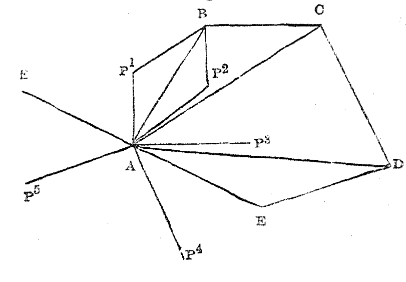
Fig. 2.



three weights, W_1, W_2, W_3 (fig. 2), the cords from which pass over three pulleys, P_1, P_2, P_3. Let the three weights come to rest, then O is the point at which the forces meet, being represented in direction by the cords, and if the apparatus is placed in front of a large board, lines coinciding with the direction of the cords O P_1, O P_2, O P_3 can be traced upon it. If, then, the number of ounces in the weight W_1 be set off in inches along the line O P_1 at P, and the number of ounces in W_2 be set off along O P_2 at Q, and the parallelogram O P R Q completed, the diagonal O R is exactly equal to and in a right line with O S, proving that the components W_1, W_2, acting along their cords on the point O, being expressed by the sides of a parallelogram, its diagonal will express their resultant, since it is equal and opposite to the force O S exerted by the weight W_3 on the point O, which is therefore in equilibrium. If parallelograms are constructed on either of the other two pairs, W_1, W_3 or W_2, W_3, in each case the remaining third force will balance the resultant of the other two. Therefore any one of three forces in equilibrium and acting on a point, will be expressed by a line equal and opposite to the diagonal of the parallelogram formed by the other two.

When more than three forces act on a point and in one plane, in estimating the statical effect of the forces, any two of the forces may be represented by their resultant. In the same way a second resultant of the first one and a third force is found, and so on, combining them one by one together into the whole effect of the system of forces. Let A P^1, A P^2, A P^3, A P^4, A P^5 (fig. 3) be forces acting on a point A. It is immaterial in what order the forces are combined, the resultant is the same. The two forces, A P^1, A P^2, being completed into a

Fig. 3.

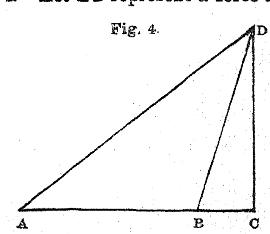


parallelogram by drawing P^2 B, P^1 B parallel to them, the diagonal A B is their resultant; in the same way, completing the parallelogram of the resultant A B and P^3, the diagonal A C is obtained, the resultant of the two forces, and so on. Another method would be to draw P^1 B parallel and equal to A P^2, and towards the same part of the plane, thus at once obtaining the resultant A B. To combine A B and A P^3, draw B C equal and parallel to A P^3, and A C is their resultant, and of course is the resultant also of A P^1, A P^2, A P^3 combined. Again, draw C D equal and parallel to A P^4, the next force, and join A D for the next resultant. Lastly, draw D E equal and parallel to the remaining force, A P^5, and A E, the last resultant, will represent the equivalent of the effects of the five forces. The point A therefore, acted on by these forces, is urged in the direction A E by a force equal to it in magnitude. To establish equilibrium, the force A E^2, or a system of forces whose resultant is A E^2, equal and opposite in direction, must be added.

The figure A P^1 B C D E, formed by drawing its sides successively equal and parallel to the forces A P^1, A P^2, A P^3, &c., is termed the polygon of the forces of the system from which it is constructed.

An important geometrical form of the law of equality of moments is illustrated in fig. 4. Let A B represent a force in magnitude and direction, then its moment in relation to any point, D, is equal to A B × D C, the perpendicular dropped on it from D. Join D A, D B, and the area of the triangle D A B = A B × $\frac{1}{2}$ D C. Therefore the moment of the force A B, in relation to D, is twice the area of that triangle, from which the following law is enunciated:—"If any number of forces, acting in the same plane, and being in equilibrium, are represented by lines, and the extremities of all these lines are joined with any point in the plane, the sum of the areas of the triangles thus formed, which have for their bases forces tending to turn the system in one direction round the point, shall be equal to the sum of those having for their bases those forces tending to turn it in the opposite direction."

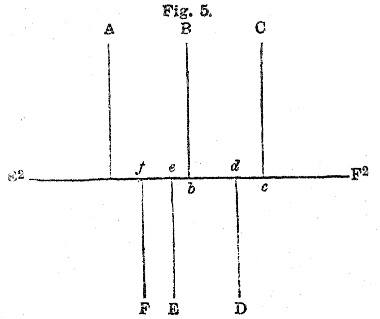
Fig. 4.



In those systems of parallel forces in which all act in the same plane, a line which is perpendicular to one will be so to all. If, therefore, A, B, C, D, E, F be a system of parallel forces in equilibrium (fig. 5), and E^2F^2 be a perpendicular to them, produce their directions to meet it in *a*, *b*, *c*, *d*, *e*, *f*. Since they may act in any point in their directions without affecting their equilibrium, let them be applied at these points. Therefore, by applying the conditions of equilibrium in reference to the point E^2, the sum of the moments of the three forces A, B, C, acting in one direction, is equal to that of the sum of the moments of the forces D, E, F, acting oppositely, and their equilibrium about any point resolves itself into that of action and reaction, as they then act in the same straight line in opposite directions, the sum of A, B, C being equal to that

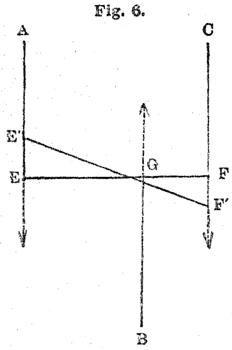
of D, E, F. When three parallel forces acting on a straight line are in equilibrium, two of them will be opposed to the third, which must act between them, and be equal and opposite to

Fig. 5.



their resultant. Let A, B, C be three forces acting on the line E F G (fig. 6). Then applying the equality of moments in reference to the point G, A and C act in opposite directions, while B has no moment at all, as it acts directly on G. The moments of A and C must therefore be equal about the point G, and A × E G = C × F G, and therefore A : C : : F G : E G; that is, the extreme forces are inversely as their distance from the middle one. In general, of three parallel forces acting in equilibrium on an inflexible line, the first is to the third as the distance of the third from the second is to that of the first from the second, and the sum of the first and third is equal to the second. If the line E F change its position for any obliquity with the forces, as the position E′ F′, then as G E and G F are still the distances of the forces A and C from G, the forces A, B, C will yet be in equilibrium.

Fig. 6.



Whenever a system of parallel forces reduces to a single resultant, those forces have a centre; that is to say, if each of the forces acts at a fixed point, there will be a point through which the direction of the resultant will pass when the directions of the forces are turned through any equal angles round their points of application in such a manner as to preserve the parallelism of their directions. This is illustrated when the parallel forces are the weights of the respective molecules or particles of matter forming a solid body, and the forces all acting towards the same part will have as a resultant their sum. If the body be held in different positions, the lines of direction of the resultant will all intersect in one point, their centre. That point is called the *centre of gravity* of the body.

CHAPTER V.

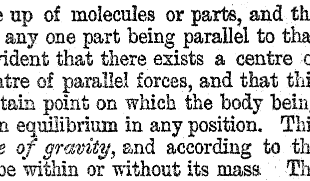
GRAVITATION — CAVENDISH'S EXPERIMENT — CENTRE OF GRAVITY — STABILITY — LAWS OF FALLING BODIES — ACCELERATION—PROJECTILES—MEASUREMENT OF VELOCITY OF DESCENT—PENDULUM—COMPOUND PENDULUM—SECONDS PENDULUM — CAUSES MODIFYING TERRESTRIAL GRAVITATION—APPLICATION OF PENDULUM TO CLOCKS—BALLISTIC PENDULUM.

THE force or mutual action by which the material particles of all bodies tend incessantly to approach each other, and which all bodies, either at rest or in motion, exert upon one another, is termed *gravitation*. The existence of a mutual attraction between the masses of the sun, the earth, and the planets was assumed by Kepler, and the theory of gravitation was likewise recognized by Bacon, Galileo, and Hooke. But Sir Isaac Newton was the first mathematician who established the law of *universal gravitation*, and demonstrated that the same law by which bodies at the earth's surface descend, preserves the planets in their orbits, and regulates their motions; and Newton was the first who showed that Kepler's laws were necessary, upon the supposition of an attraction inversely as the square of the distance, and impossible upon any other hypothesis. This law, which expresses the attraction of each particle of matter of the one body upon every particle of matter of the other, may be stated in general terms to be, that the attraction between any two material particles of matter is directly proportional to the product of their masses, and inversely proportional to the square of their distances from one another. The actual existence of the attraction of particle on particle is proved by Cavendish's experiment, made at the end of last century. Small leaden balls were supported on the ends of a rod, which was suspended at the middle by a very fine wire; and when large leaden balls were brought near to them, it was found that the wire was twisted by the motion of the balls. The great value of Cavendish's experiment is, that it demonstrates that there is a small force directed to every different particle of the earth. The attractions of large masses, as mountains, have been found to produce sensible effects in changing the general direction of the force of gravity at stations near such masses. In 1772 Dr. Maskelyne experimented on the attractive influence of a mountain ridge running east and west in Perthshire, for the purpose of determining the amount of lateral attraction upon the plumb-line. Two stations were selected, one on the north and the other on the south side of the Schiehallion, and it was found that the angle between the directions of the plumb-lines at each station was greater by 11·6″ than the angle between the normal of the mean surface of the earth at those places, so that each plummet was deflected by about 6 seconds towards the mountain.

Every body being made up of molecules or parts, and the attraction of the earth on any one part being parallel to that on any other part, it is evident that there exists a centre of weight which is also a centre of parallel forces, and that this centre of weight is a certain point on which the body being freely suspended, will be in equilibrium in any position. This point is called the *centre of gravity*, and according to the form of the body it may be within or without its mass. The determination of the centre of gravity of a body is entirely a geometrical problem, but it may readily be found by experiment. As the weight of a body is not a single force, but is the resultant of a series of parallel forces, it follows that when a body is suspended by a cord, the tension of the cord must be equal and opposite to the sum of the vertical forces due to the weights of the several parts. The cord will therefore hang in a vertical direction, and the centre of gravity of the body will be somewhere in the direction of the line of the cord. If the point of suspension be changed, a second line will be recorded which also passes through the centre of gravity of the body; the point where these lines intersect each other is the *centre of gravity* of the body. In figures or bodies of equal density throughout, such as spheres, cubes, circles, squares, &c., the centre of gravity is always the centre of the figure; in cylindrical rods it is the middle point of the axis.

The centre of gravity of a triangle is found by drawing lines from any two of the angles to bisect the opposite side, as in fig. 7, in which the two sides B A and B C of the triangle B A C are bisected at D and E, and the lines D C and E A are drawn to the two angles C and A respectively; the point of their intersection, G, will be the centre of gravity of the triangle B A C.

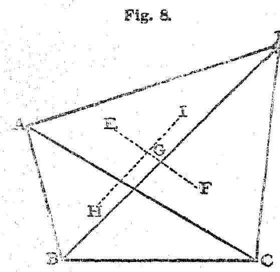
Fig. 7.



If the points D, E, be joined by the line D E, then by similar triangles DGE, AGC, AG : CE = AC : DE = BC : BE = 2 : 1. Therefore A G = 2 G E, and A E = 3 GE, or G E = $\frac{1}{3}$ E A, and A G = $\frac{2}{3}$ A E. Therefore, if a straight line be drawn from the angle of a triangle to the middle of the opposite side, the centre of gravity of the triangle will be on this line, at a distance from the angular point equal to two-thirds of the length of the line, and if three bodies of equal weight be placed at A, B, C, the centre of gravity will be the same as that of the triangle A B C.

The centre of gravity of a trapezium (fig. 8) is found by dividing the trapezium A B C D into two triangles by the diagonal B D, and then finding E, F, the centres of gravity of the two triangles; the centre of gravity of the trapezium will then lie in the line E F connecting them. Divide the trapezium into other two triangles, B A C, D A C, by the other diagonal, A C, and let the centres of gravity, H and I, of these two triangles be likewise found, then the centre of gravity of the trapezium will also lie in the line H I, so that, lying in both lines E F, H I, it will be at their intersection, G. In a similar manner the centre of gravity for a figure of any greater number of sides may be found, by finding the centres of their component triangles and trapeziums, and then finding the common centre of every two of them, until they be all reduced to one.

Fig. 8.



The *stability* of a body depends upon the position of the centre of gravity with reference to its base—that is, if a perpendicular be let fall from the centre of gravity, and it falls within the base, then its equilibrium is stable, and any tendency to turn over is neutralized, because to do so the centre of gravity would have to rise; but if the perpendicular fall without the base, then the body will tumble over on that side, because in turning over the centre of gravity will descend. It is for this reason that the leaning tower of Pisa continues to stand, because a vertical line drawn through its centre of gravity falls within its base; and the same reason applies to the leaning tower of Caerphilly Castle, South Wales. As the centre of gravity in every body naturally tends to occupy the lowest possible position, bodies are divided into three conditions of equilibrium—*stable*, *unstable*, and *neutral*. A body is in *stable* equilibrium if it returns to its first position after the equilibrium has been slightly disturbed, so that whenever a slight change of position elevates the centre of gravity it will, after a few oscillations, return to its original position, as the centre of gravity will descend again when permitted. A pendulum continually oscillates about its position of stable equilibrium. An egg is likewise in stable equilibrium when its length is lying horizontal on a level board. A body is said to be in *unstable* equilibrium when, after the slightest motion, it tends to depart still further from its original position. A body is in unstable equilibrium when its centre of gravity is vertically above the point of support, or higher than it would be in any other position the body could assume. A body is in *neutral* equilibrium when any alteration of the position of the body neither raises nor lowers its centre of gravity. A sphere resting on a horizontal plane is in this state.

As the force of gravity is uniform at all places at the same distance from the earth's centre, and a body falls to the ground by reason of the earth's attraction on each of its molecules, the force by which it is attracted will act on every body, large, small, heavy, or light, with the same force, and every body will fall perpendicularly through *equal spaces* in *equal times* when not affected by the retarding influence of the resistance of the air. A feather and a sovereign will fall in an exhausted receiver the same distance in exactly the same time (fig. 1, Plate I.), and the fact that a stone falls more rapidly than a feather in air is simply owing to the unequal resistance opposed by the atmosphere to their descent. It is also demonstrated that the *velocities* acquired by a falling body are in the exact proportion of the times of descent, and that the *distances* through which the body has fallen are proportional to the square of the times, and therefore to the square of the velocities; so that the weights of bodies near the earth's surface being proportional to the quantities of matter they contain, the spaces, times, and velocities generated by gravity in a falling body are in accordance with the three general proportions above named.

It has been determined by accurate experiment that a body in the latitude of London descends with a velocity of 16·095 feet in a second; this number, however, varies with the latitude, on account of the spheroidal form of the mass of the earth. In latitude 45°, near Bordeaux, it has a value of 16·085 feet in a second. It is well known that the greater the height is from which a body falls, the greater is the force with which it strikes the earth, and that this is entirely due to the greater velocity imparted by gravity to the body in falling from the greater height. This velocity imparted to the body falling is not, however, proportional to the height from which it falls; if the height be increased four times, the velocity is augmented only twofold; and if the height be augmented ninefold, the velocity is increased only threefold, or the velocity is proportional to the square root of the height.

As a body in the latitude of London falls 16·1 feet in the first second of time, at the end of that time it will have acquired a velocity double of its mean velocity, or of 32·2 feet per second; therefore if g denote 16·1 feet, the space fallen through in one second of time, or $2g$ the velocity generated in that time, then, as the velocities are directly proportional to the times, and the spaces to the square of the times,

$$1'' : t :: 2g : 2gt = v, \text{ the velocity acquired, and}$$
$$1^2 : t^2 :: g : gt^2 = s, \text{ the space described.}$$

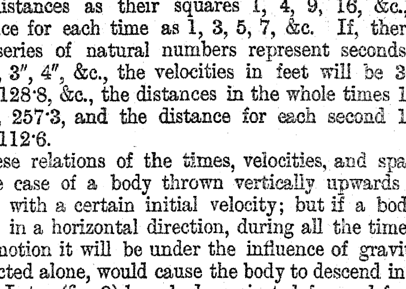
From these two proportions, therefore, the following equations are derived for the descent of bodies by the force of gravity, viz.:—

$$s = gt^2 = \frac{v^2}{4g} = \tfrac{1}{2}tv.$$
$$v = 2gt = \frac{2s}{t} = 2\sqrt{gs}.$$
$$t = \frac{v}{2g} = \frac{2s}{v} = \sqrt{\frac{s}{g}}.$$
$$g = \frac{v}{2t} = \frac{s}{t^2} = \frac{v^2}{4s}.$$

So that the times are as the velocities, and the distances as the squares of either; therefore, if the times be as the numbers 1, 2, 3, 4, &c., the velocities will be as 1, 2, 3, 4, &c., the distances as their squares 1, 4, 9, 16, &c., and the distance for each time as 1, 3, 5, 7, &c. If, therefore, the first series of natural numbers represent seconds of time, 1″, 2″, 3″, 4″, &c., the velocities in feet will be 32·2, 64·4, 96·6, 128·8, &c., the distances in the whole times 16·1, 64·3, 144·8, 257·3, and the distance for each second 16·2, 48·6, 80·5, 112·6.

These relations of the times, velocities, and spaces apply to the case of a body thrown vertically upwards or downwards with a certain initial velocity; but if a body be projected in a horizontal direction, during all the time the body is in motion it will be under the influence of gravity, which, if it acted alone, would cause the body to descend in a vertical line. Let A (fig. 9) be a body projected forward from A, with

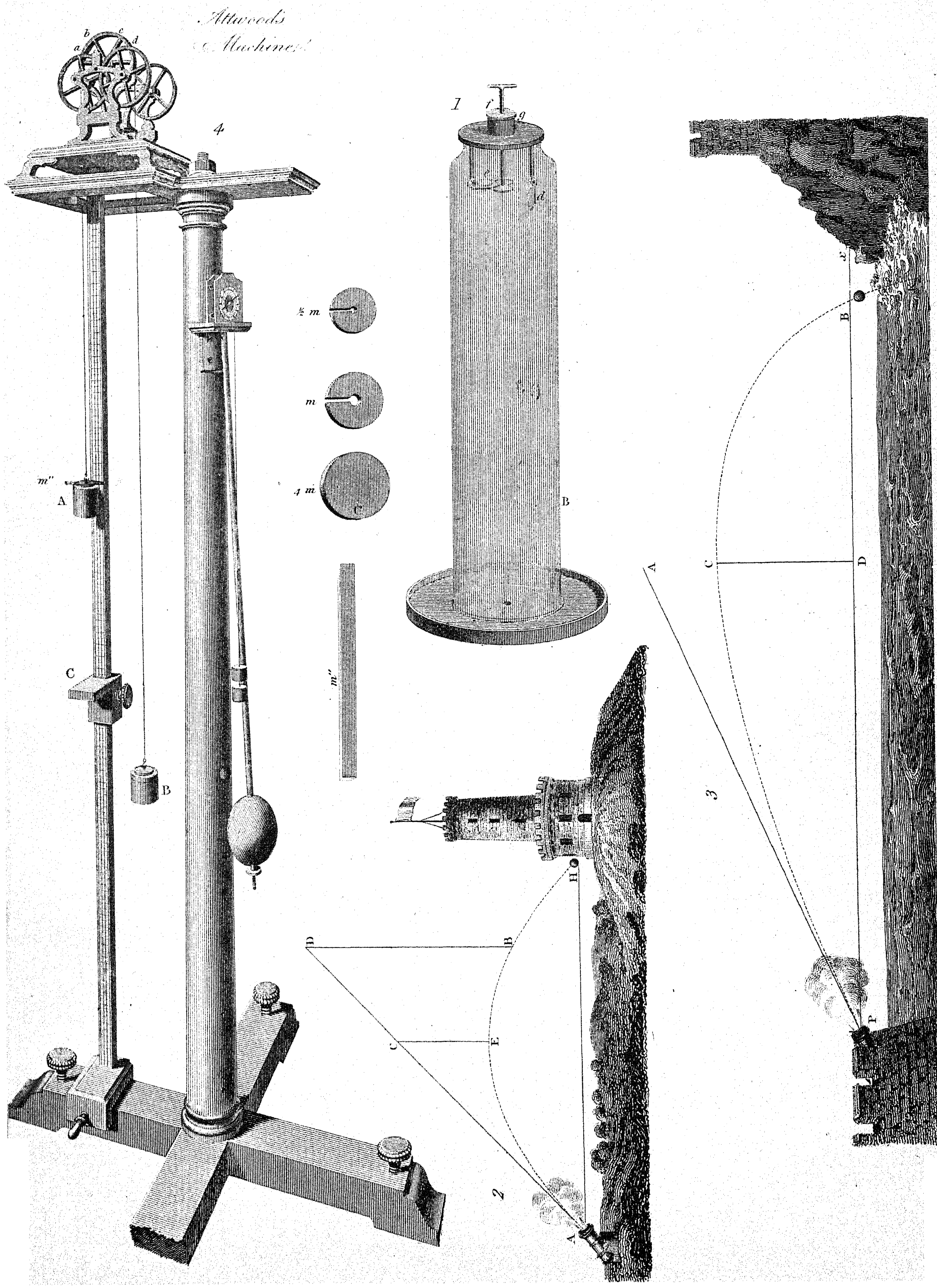
Fig. 9.



a certain initial velocity of v feet in a second, in the direction A x; then, at the end of the 2–3 equal intervals, the body by reason of its inertia will have reached the points a, a', in the line A x. Had the body A been simply acted upon by gravity it would have descended in the same moments of time through the distance c c' represented on the vertical line A y; and the effect of the combined action of the two forces is that at the end of the several intervals the body will be at the respective points where these lines intersect, and it will thus

NATURAL PHILOSOPHY.

GRAVITATION.



describe a curved path; and as the laws for the destruction of motion are the same as those for the generation of motion, it follows that a body thrown directly upwards, with any velocity, will lose equal velocities in equal times.

The *velocity* or acceleration produced by gravity, acquired by a body falling from a state of rest, is equal to the product of the intensity of gravity, and the number of seconds the body has been falling, or $v=gt$. The *distance* passed over by a moving body is always equal to *the product of its mean velocity and the time*, and as bodies gain velocity at a uniform rate, the *mean velocity* of a body falling from a condition of rest will be *one-half* the velocity it has acquired; therefore, as the velocity is $=gt$, the mean velocity will be $\frac{1}{2}gt$, and the space $s=\frac{1}{2}gt \times t=\frac{1}{2}gt^2$; and as $v=gt$, then $t=\frac{v}{g}$, and by substitution $s=\frac{1}{2}gt^2=\frac{v^2}{2g}$.

If the direction in which the body is projected makes an angle with the horizon it will, by the combined effect of this motion and the action of gravity, describe the curve line of a *parabola*. Let A (fig. 2, Plate I.) be the body projected from the point A in the direction AD, with any uniform velocity; then in any equal portions of time it would describe equal spaces in the line AD, or in the third interval the space CD, equal to one-half of the distance AC, if it were not drawn continually down below the line AD by the action of gravity. Draw CE and DB in the direction of gravity perpendicular to the horizon and equal to the spaces through which the body would descend by its gravity in the same time in which it would uniformly pass over the corresponding spaces in the line AD by the projectile motion. Then, since by these two motions the body is carried over the equal spaces in AD in the same time as the corresponding spaces CE, DB, at the end of those times the body will be found respectively at the points E and B, and the path of the projectile will be the curve AEBH. But the equal spaces in the line AD described by uniform motion are as the times of description, and the spaces CE, DB described in the same time by the accelerating force of gravity are as the squares of the times; therefore the perpendicular descents are as the squares of the spaces in AD, which is the property of the *parabola*.

If the direction in which the body is thrown makes an angle, P (fig. 3, Plate I.), with the horizon, then after t seconds it would have travelled a distance $PA=vt$, where v is the original velocity. During this time by the action of gravity it will have fallen through a distance $AC=\frac{1}{2}gt^2$, and the height which it will have actually reached is $AD-AC=vt \sin a-\frac{1}{2}gt^2$, and the horizontal distance will be $PD=PA \cos P=vt \cos P$. The *range* of the body, or the greatest distance through which it is thrown, will be reached when the height is again $=0$; that is, when $vt \sin P-\frac{1}{2}gt=0$, from which $t=\frac{2v \sin P}{g}$. Substituting this value of t into the equation for the distance d, then $d=\frac{2v^2 \sin P \cos P}{g}$, which by a trigonometrical substitution $=\frac{v^2 \sin 2P}{g}$. The highest altitude is attained in half the time of flight, or when $t=\frac{v \sin P}{g}$, from which is obtained $h=\frac{v^2 \sin^2 P}{2g}$. The height, therefore, is greatest when sin P is greatest, which is when it equals 90° or when the body is projected vertically upwards; the range is greatest when sin 2P is a maximum—that is, when 2P equals 90° or $P=45°$. In these formulæ the resistance of the air has not been taken into consideration, and in practice, more especially if the velocity of the body is very great, the path differs from that of a parabola (fig. 2), and is approximately represented by the path shown in fig. 3, allowing for the resistance of the air.

The resistance that the air opposes to bodies falling from a great height with accelerated velocity is very great, but when a body falls from a comparatively small elevation the resistance may be considered as uniform and continuous. Various instruments have been devised for experimentally verifying the laws of falling bodies discovered by Galileo at the commencement of the seventeenth century. The great object of all such instruments is to reduce the rapidity with which a body falls, without altering the character of its motion, so that by this means its motion may be observed, and the retardation from the resistance of the air considerably lessened. One of the most convenient forms of instrument for this purpose is shown at fig. 4, Plate I.

A stout pillar of wood, about 7 feet 6 inches in height, is fixed upon a stand. This stand is provided with levelling screws to adjust the apparatus, so that the index post may be perpendicular with the horizon. The top of this pillar carries a frame upon which a brass pulley, *a b c d*, is mounted, the axle of which rests and turns upon four *friction wheels*, so as to reduce the friction of the revolution of the pulley on its axle to a minimum. Two equal weights, A, B, are attached to the extremities of a fine silk thread, which passes round the pulley *a b c d*, and the weights A and B are therefore in equilibrium.

A timepiece is fixed to the upper part of the wooden pillar, the motion of which is regulated by a seconds pendulum, and a seconds hand on the dial-plate of the clock indicates seconds. The weights A and B being equal balance each other; the weight A, however, is made to descend slowly by the addition of a small bar or overweight m''. To measure the spaces which the weight A describes in falling, a graduated scale divided into feet and inches is attached to the frame. A hollow ring, through which the weight A can pass in its descent, is attached to the scale by a movable clamp at any desired position, its object being to arrest the bar or overweight as the weight A passes through the ring, allowing the weight to descend forward in consequence of its inertia uniformly with the velocity it had acquired on reaching the ring. The movable table C attached to the scale arrests the motion of the descending weight A at any required distance. The balancing weights and the overweight are shown enlarged at $\frac{1}{2}m$, m, $4m$, and m''. If the weights be so adjusted that the descending weight will describe exactly one foot in the first second, indicated by the beat of the pendulum, it will be found to descend through 3 feet in the next, and 4 feet in the third second. If, however, the accelerating weight m'' be arrested at the end of the first second by a perforated stage through which the weight A passes freely, it will now be found to descend uniformly through *two* feet during each succeeding second, as its velocity at the end of the first second is double its mean velocity.

The dimensions of the earth present a natural unit of the measure of space, upon which, by actual measurement, the French unit of linear measurement, the mètre, has been determined; but when it is considered that the *quantity directly measured* is a length a great many thousand times the final unit, and in the *pendulum* (or yard very nearly), the unit itself, it is evident that the mètre is the most accurate as an original measure, because any error committed in the first process by which that is determined becomes subdivided in the final result, while any error committed in determining the length of the pendulum becomes multiplied by the repetition of the unit in all measurements of considerable lengths performed in yards. The pendulum affords a means of subdividing time to an almost unlimited nicety. A clock is simply a piece of mechanism constructed to register the oscillations of a pendulum; and from the peculiar property of the pendulum, that one vibration commences exactly where the last terminates, no part of time is lost or gained in the juxtaposition of the units counted, so that the precise fractional part of a day can be ascertained which each such unit measures.

A *pendulum* consists of a ball or heavy body suspended by a fine string, and free to oscillate backwards and forwards about the centre of suspension, describing an arc of a circle. The weight of the pendulum is therefore in its motions influenced by the same forces as would act on any body descending by its gravity along the spherical superficies of the arc it describes, if that superficies were perfectly hard and smooth. When the ball is set swinging the velocity that it has acquired in reaching the perpendicular position or centre of the arc will be sufficient to cause it to ascend through an equal arc to the same height from which it originally fell; and having then lost all its motion it will again descend by

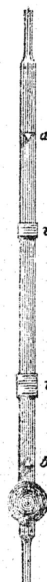
its own gravity, and in the lowest point will acquire the same velocity as before, which will cause it to ascend to the point from which it originally started. If the motion of the pendulum met with no resistance from the air, and was free of friction about the centre of motion, its vibrations would continue for ever; but from these causes the velocity of the ball at the centre of the arc of vibration is each time diminished, and therefore does not return precisely to the same points; so that the arc described continually becomes shorter and shorter, until at length the pendulum is brought to rest by the force of gravity, unless the motion is assisted mechanically by the maintaining power of a clock. The law which governs the vibration of a simple pendulum is—that the time of vibration increases as the square root of the length of the pendulum, and decreases as the square root of the intensity of gravity increases; also, that for very small vibrations, when the amplitude of the arc does not exceed 3 or 4 degrees, the time of vibration is independent of the amplitude.

The pendulum has, so far, been considered as a simple pendulum, that is, a thread without weight, to the end of which is attached a heavy body, which oscillates freely backwards and forwards. As, however, in practice this theoretical pendulum has to give place to a pendulum composed of a heavy rod terminated by a greater or less weight, it is termed a *compound pendulum*, and the length of the compound pendulum to vibrate *seconds* of time has to be determined. The laws for the time of vibration of the compound pendulum are the same as those regulating the simple pendulum; but as the rod is a material body, the several particles of which it is constituted will endeavour to perform their oscillations in different times, according to the difference of their distances from the point of suspension, those furthest removed from it requiring a longer time to complete a vibration than those particles situated near to the axis of suspension; being, however, all particles in the same body, they are forced to oscillate together, and therefore the particles further removed will experience an acceleration of motion, while on the other hand those near the axis of suspension will be subjected to a retarding influence. At some point therefore between the two extremities of the pendulum the particles will be neutral as regards these two influences, and will oscillate with a motion neither accelerated nor retarded, but will move freely and independent of the motion of the other particles, and constitute a parallel axis of their own, termed the *centre of oscillation*, equidistant between the two axes of the pendulum; and the distance between the two axes determines the length of the compound pendulum, which is that of the simple pendulum describing its oscillations in the same time.

As all the vibrations of a pendulum moving in a cycloid are performed in the same time—which time is to the time of a body falling through the centre of oscillation, or half the length of the pendulum, as 3·1416 : 1, the ratio of the circumference to its diameter—the time of vibration of a pendulum is easily determined. Let $p=3{\cdot}1416$, l the length of the pendulum, and g the space fallen by a heavy body in a second of time: then $\sqrt{g} : \sqrt{\frac{1}{2}l} :: 1'' : \sqrt{\frac{l}{2g}}$, the time of falling through $\frac{1}{2}l$; therefore $1 : p :: \sqrt{\frac{l}{2g}} : p\sqrt{\frac{l}{2g}}$, which gives the time of one vibration of the pendulum. As the time of vibration of a pendulum moving in a small arc of a circle nearly coincides with that of the vibration in a small cycloidal arc, the time of vibration in a small circular arc is equal to $p\sqrt{\frac{l}{2g}}$, where l is the radius of the circle. Therefore, if either g or l is determined by experiment this formula will give the other, so that if the space fallen through by a heavy body in a second of time be ascertained, the length of the seconds pendulum can be determined; or, if the length of the pendulum is known, the space fallen by a body in one second is ascertained. In the latitude of London, the length of the seconds pendulum is $39\frac{1}{8}$ inches, and substituting l for this length, $p\sqrt{\frac{39\frac{1}{8}}{2g}} = 1''$ or $9 = \frac{1}{2}p^2 l = \frac{1}{2}p^2 \times 39\frac{1}{8} = 193{\cdot}07$ inches, which equals $16\frac{1}{12}$ feet, for the descent of gravity in one second. From this also may be found the length of a pendulum that shall make any number of vibrations in a given time, or the number of vibrations that shall be made by a pendulum of a given length.

If it is required to find the length of a half-seconds pendulum, or a quarter-seconds pendulum—that is, a pendulum to vibrate twice in a second or four times in a second—then, as the time of vibration is as the square root of the length, $1 : \frac{1}{2} :: \sqrt{39\frac{1}{8}} : \sqrt{l}$, or $1 : \frac{1}{4} :: 39\frac{1}{8} : \frac{39\frac{1}{8}}{4} = 9\frac{3}{4}$ inches about, or the length of the half-seconds pendulum. Again, $1 : \frac{1}{16} :: 39\frac{1}{8} : 2\frac{4}{9}$ inches, which will be the length of the quarter-seconds pendulum. Again, if it is desired to determine the number of vibrations that a pendulum 80 inches long will make in a minute, $80 : \sqrt{39\frac{1}{8}} :: 60''$, or $1' : 60\sqrt{\frac{39\frac{1}{8}}{80}} = 7\frac{1}{2}\sqrt{31{\cdot}3} = 41{\cdot}95987$, or nearly forty-two vibrations in a minute. As before stated, in all these calculations the thread is supposed to be very fine, or of no sensible weight, and the ball of the pendulum very small, so that all the particles of matter are united about one point; also, that the length of the pendulum is the distance from the point of the centre of motion to the centre of the small ball. If the ball be large and heavy, and a thick cord or a rod be employed, then the length of the pendulum is measured from the centre of suspension, not to the centre of magnitude of the ball, but to such a point as that if all the matter of the pendulum were collected into it, it would then vibrate in the same time as the *compound pendulum*, this point being the *centre of oscillation*. The Dutch physicist, Huyghens, discovered that the axes of suspension and oscillation of a pendulum are mutually convertible, and that the time of oscillation of the pendulum remains the same from whichever axis it is suspended. This has enabled the length of the compound pendulum to be determined experimentally. For this purpose the "reversible pendulum," fig. 10, may be used. This is a rod with the knife edges a and b turned towards each other; w and v are weights the relative positions of which may be changed. By a series of trials a position can be found such that the number of beats of the pendulum in a given time is the same whether it is suspended from a or b. This being so, the distance $a\,b$ represents the length of a simple pendulum which has the same time of oscillation. As the intensity of gravity varies at different places on the earth's surface, so the length of the seconds pendulum also varies at those different places. The length of the seconds pendulum and the accelerative effect of gravity for the following places is given in the annexed table.

Fig. 10.



	Latitude.	Length of Pendulum in Inches.	Accelera-tion of Gravity. Feet.	Accelera-tion of Gravity. Mètres.
Hammerfest, ...	70° 40′ N.	39·1948	32·2364	9·8258
Königsberg, ...	54° 42′	39·1507	32·2002	9·8142
Manchester, ...	53° 29′	39·1472	32·1972	9·8132
Berlin, ...	52° 30′	39·1439	32·1945	9·8124
Greenwich, ...	51° 29′	39·1398	32·1912	9·8115
Paris, ...	48° 50′	39·1285	32·1819	9·8039
New York, ...	40° 43′	39·1012	32·1594	9·8019
Washington, ...	38° 54′	39·0968	32·1558	9·8006
Madras, ...	13° 4′	39·0268	32·0992	9·7836
Ascension, ...	7° 56′	39·0242	32·0939	9·7817
St. Thomas, ...	0° 25′	39·0207	32·0957	9·7826
Cape of Good Hope, .	33° 55′ S.	39·0780	32·1404	9·7962

It is by comparing observations of this kind, and allowing for the effects of rotation, that the form of the mass of the earth has been definitely determined. It has been already stated that the intensity of the force of gravity is modified by several causes, of which the form of the earth and its rotation on its axis are the two most important. The attraction of the earth on any body at its surface being the sum of the partial attractions which each particle of the earth exerts upon each particle of that body, the resultant

of all these attractions may be concentrated in a single point, the earth's centre. If the earth were a true sphere, any given body would be equally attracted at any part of the earth's surface, the attraction decreasing with its elevation above the surface; the attraction of gravitation being inversely as the square of the distance from the centre. Let g be the value of the acceleration of gravity at the sea-level; g' its value at any height, h; and R the radius of the earth. The distance h being so small in comparison with R, its square may be omitted. With these elements the following formula is obtained:—$g' = \dfrac{g}{1 + \frac{2h}{R}}$, or $g' = \dfrac{gR}{R + 2h}$. The earth being an ellipsoid in which the major axis is to the minor axis as 12,754,796 mètres to 12,712,160 mètres, the force of gravity at the sea-level is not constant, but varies in different parts of the earth's surface.

Calculation shows that the force of attraction at the poles of the earth is $\frac{1}{578}$ greater than at the equator, supposing the earth were at rest. Owing, however, to the earth's rotation the force of gravity is further modified. No body on the earth's surface is at rest, but only relatively so with respect to other bodies around it. A body on the earth's surface at the equator will revolve with the earth, and will in the course of twenty-four hours describe a circle, the radius of which is that of the earth; and as every body by reason of its inertia tends to move in a straight line, to cause it to move in a circle a force must be exerted at each instant to overcome its tangential inclinations. Therefore a certain portion of the earth's attraction is absorbed in retaining the body upon the earth's surface, and only the residue becomes apparent as *weight* or *accelerating force.* This absorption of the earth's attractive power amounts to $\frac{1}{289}$ part of the attraction the earth would exert were its mass at rest. The nearer a body approaches the poles, the less is the force of gravity diminished by the effect of the centrifugal force; from the combined influence of these two causes, the flattening at the poles and the centrifugal force, the effect of the attraction of gravity at the equator is reduced by about $\frac{1}{192}$ part of its value at the poles.

The most important use to which the pendulum has been applied is its application to the clock as an instrument for *measuring time*, the clock being simply an apparatus for keeping the pendulum in motion, and recording the number of its oscillations. Pendulums were first employed for this purpose by Huyghens in 1658. The clock generally consists of an *escapement wheel* in connection with a train of wheel-work set in motion by the gravity of a falling weight, or the tension of a coiled spring, and the regularity of the motion of which is determined by the oscillations of the pendulum. The escapement wheel, which revolves on its axis, is arrested in its forward motion, tooth by tooth, by means of an *escapement*, or lever bent at each arm to form a double hook, which alternately releases and checks a tooth of the escapement wheel, as the oscillations of the pendulum are communicated to it by means of a rod or crutch attached to its axle, and furnished with a bent fork at the lower end, between the prongs of which the rod of the pendulum works, and in its oscillations moves it from side to side over the teeth of the escapement wheel. At the time the escapement slips over the tooth on one side, the escapement wheel gives it a slight impulse, which by means of the crutch is conveyed to the pendulum, thus compensating its tendency to return to a state of rest by the effects of friction. As each tooth of the escapement wheel is caught twice by the escapement, once for each forward and backward oscillation of the pendulum, if the wheel has thirty teeth it will make one revolution for every sixty beats of the pendulum. The axis of the escapement wheel carries an index termed the *seconds-hand* of the clock, which in this case registers in one revolution of the escapement wheel sixty beats of the pendulum. The next wheel in connection with the escapement wheel revolves in sixty revolutions of the former, or once in the hour. This, therefore, registers the minutes by means of a *minute-hand;* and this second wheel is geared into a third, which revolves once in twelve revolutions of the last, and registers the hours by an index, the *hour-hand.* Thus the descent of the weight is alternately checked and released or regulated by the uniform motion of the pendulum. The energy consumed in overcoming the friction of the axis of the pendulum, and the train of wheels in the clock, and the resistance of the air, is compensated by the falling weight or uncoiling spring, and when this is consumed it is renewed by the raising of the weight or recoiling of the spring. This renewal of energy is therefore derived from the power or force furnished by the hand or arm of the person winding up the clock.

The *ballistic pendulum*, invented by Robins, is employed to determine the initial velocities of projectiles, a circumstance of great importance in the science of gunnery. It consists of a large block of wood, coated with iron and weighing from 3 to 5 tons. This mass is suspended vertically by a strong iron axis, to which it is connected by a firm iron stem passing through the block. The ball, the velocity of which is to be measured, is fired against this mass, and the deflection produced by impact being noted the velocity of the ball may be calculated from the laws of the impact of elastic bodies, shortly to be explained, and from those of the pendulum.

ARITHMETIC.—CHAPTER II.

FUNDAMENTAL OPERATIONS OF ARITHMETIC.

I. ADDITION.—II. SUBTRACTION.

ALL processes in arithmetic consist in the increase or diminution of numbers, and might consequently all be performed with pebbles. But shorter and less complex ways of counting have been invented, by which, in many cases, the labour of years is reduced to the work of a few minutes, and we are enabled to make calculations with facility which human patience on the old system would never have dared to undertake. The four great methods we employ are denominated Addition, Subtraction, Multiplication, and Division; but the two last, as we shall afterwards see, are only convenient modes of doing several of the first and second at once. To give a general notion of these methods and their connections, we shall consider, in the first place, their applications to the management of numbers expressed by single figures.

1. *Addition.*—This is the name given to the operation by which several numbers are collected into one whole, called the *sum.* It is founded on the principle, that "a whole is equal to all its parts taken together." Thus nine halfpence may be disposed of in three groups, the first containing two, the second four, and the third three halfpence; and when we have collected together the halfpence in these groups into one total, and written the numerical sign, we have done a case of addition. To *add* numbers together means, therefore, nothing more than to find out a single number the name of which shall truly express the entire value of the several groups taken collectively.

Every number which consists of several units may be regarded as a *sum* formed by the successive addition of these units. Thus 2 is the sum of 1 and 1 more, 3 is the sum of 2 and 1 more, and so on; and however high a number may be, it is simply a sum of *ones.*

2. To render the language of arithmetic shorter, we use a few arbitrary signs to denote the operations which are to be performed upon the numbers with which we are dealing. The sign by which we express that two numbers are to be added together is a St. George's cross, written + and usually named *plus*, the Latin word for *more.* Thus, instead of writing "*add* 2 *and* 4 *and* 3 *together*," we write $2+4+3$, which is read 2 *plus* 4 *plus* 3; and this, when the meaning of the sign is known, is equally intelligible, while it has the advantage of being more concise.

From what has been said, we know that $2+4+3$ is truly expressed by 9; but to indicate this equivalence of value in a concise manner, we use another sign, composed of two parallel lines, thus =. This is read *equals*, and is called the *sign of equality*, because it is only used between two numbers, or collections of numbers, the values of which are exactly the same. Thus, to indicate that the value of $2+4+3$ is 9, we write $2+4+3=9$. This is called an *equation*, and is read as a whole 2 *plus* 4 *plus* 3 *equals* 9. We can, of course,

make as many such equations as we please, and the following table of them should be made three or four times over, and extended by the learner to all numbers less than 10. This will familiarize him with the signs and the addition of the simple numbers, of which large numbers are made up.

$2+2=4$	$5+7=6+6=8+4=12$
$2+4=3+3=6$	$4+9=5+8=6+7=13$
$2+6=3+5=8$	$5+9=6+8=7+7=14$
$3+7=4+6=10$	$6+9=7+8=15$
$3+8=7+4=11$	$7+9=8+8=16$
$3+9=4+8=12$	$9+8=17 \qquad 9+9=18$

3. *Multiplication.*—It frequently happens that the numbers to be added are all equal to each other, as for instance,

$$2+2+2+2+2=10$$

This species of addition takes the name of *multiplication*, and is expressed 2 *repeated* 5 *times*, or more commonly 5 *multiplied by* 2. The sign by which it is denoted is a St. Andrew's cross, written $\times$ and read *multiplied by* or more shortly *into*. Thus 5 *multiplied by* 2, or 2 *repeated* 5 *times*, is expressed symbolically by 5×2, which is the same thing as $2+2+2+2+2$, and is much shorter. Multiplication, then, is to be considered as simply a concise method of finding the sum of several numbers when they are all equal to one another, and by its rules we are often able to perform with a few figures operations which would otherwise require long and tedious reckoning.

4. *Subtraction.*—After we have learned to compose a number by the addition of several others, the first question which presents itself regarding two unequal quantities is, how much the one exceeds the other; that is, how many units must be added to a less number to make it equal to a greater, or how many must be taken away from a greater number to make it equal to a less one. Suppose we have the numbers 9 and 5 given, and we wish to find out their *difference;* two methods at once present themselves; we may take away unit after unit from 9 until 5 only are left, and the number of units so taken away will of course show the excess of 9 over 5; or we may proceed by an opposite process with 5, and find by successive additions of 1 how much it falls short of 9; both processes show that the difference between the numbers is 4, and the proof is that $5+4=9$. But this suggests that the question may be viewed more simply; for if the sum of 5 and 4 be 9, then it is obvious that we may regard 9 as composed of these two parts, and as one of them was given the whole operation comes to the taking away of the 5 from the 9. This is indicated by placing the sign $-$ between the numbers, writing the greater number on the left and the less on the right, thus $9-5$. The sign is read *minus* (the Latin word for *less*), meaning that the first number is to be *lessened* by the second; $9-5$ will then be read 9 *minus* 5, or 9 *lessened* by 5. When this operation is completed, we call the number which is left the *remainder;* but when we remark the inequality of 9 and 5, without fixing attention on the order of their magnitude, we say their *difference* is 4. We may use either of these terms, however, without risk of confusion; both denote the answer to a question in subtraction, and verbal nicety is the only reason why at times we should use the one rather than the other.

When we are able to add numbers up to $9+9$, the cases of subtraction within the same limits cannot present much difficulty; we, however, produce the following equations, for the sake of affording exercise in the use of the sign; their number may be extended at pleasure until expertness is attained.

$$5-3=2 \qquad 8-5=3 \qquad 6-2-1=3$$
$$7-3=4 \qquad 9-4=5 \qquad 9-4-3=2$$

It is obvious that in all cases the answer may be proved to be correct, or otherwise, by adding together the remainder and the number subtracted (called usually the *subtrahend*). If the same be equal to the number from which the subtraction was made (called the *minuend*), the result is correct.

Thus, $11-5=6$ because $5+6=11$
$\qquad 15-8=7$ " $8+7=15$

5. When we come to deal with cases of subtraction which involve high numbers, we shall find that *the difference between two numbers is not altered by augmenting or diminishing each by the same quantity;* that is, when adding a number to the first, if you add the same number to the second; or when subtracting a number from the first, if you subtract the same number from the second.

Thus, $3-1=5-3=7-5=9-7=11-9=2$
$\qquad 11-9=9-7=7-5=5-3=3-1=2$

Many other cases should be tried in the same way as these two, and the proposition *should not* be passed over until its truth has been perfectly comprehended. The following exercise on the signs may also be useful, as models by which to construct other cases.

$$7+3-2=8 \qquad 9-5+2=6 \qquad 8+5-4=9$$
$$7-5-1+2+5=8 \qquad 9+3-6+8-7+1=8$$

6. *Division.*—This is nothing more than a short way of performing many subtractions of the same number, just as multiplication was shown to be a ready method of performing many additions of the same number. For instance, to divide 10 by 2, is to find out how often 2 may be taken from 10. The answer is, 5 times. The sign by which we *frequently* (not always) denote division is $\div$; so that $10 \div 2$ is the short way of putting the question—*How often is it possible to subtract* 2 *from* 10? But such an expression is usually read, 10 *divided by* 2, or more shortly still, 10 *by* 2. As addition and subtraction are inverse operations—the one finding the *sum* of numbers, and the other their *difference*—and as multiplication is nothing more than a compendious mode of performing that species of addition wherein numbers to be added are the same, division may be strictly regarded as the inverse of multiplication—a concise mode of subtracting when the numbers to be subtracted are all the same, or when it is required to find how often the *same* number can be subtracted.

We shall now turn our attention to the rules of each of these fundamental operations as applied to magnitudes of all dimensions, taking them in the order at first announced—Addition, Subtraction, Multiplication, and Division. At this point we may assume that the learner is able to find out with facility the sum and difference of all numbers less than 10. Unless he can, he will make little progress in high numbers. We also advise him to make himself familiar with the meaning of the signs $+$ and $-$; for a thorough readiness in the use of these is of more importance to his successful prosecution of mathematical studies than he can possibly in the meantime comprehend. It is true, indeed, that one might acquire a sufficient knowledge of arithmetic to be able to sum up columns of pounds, shillings, and pence, without troubling oneself about either $+$ or $-$, and had we contemplated no higher end we would not have even mentioned them.

I. ADDITION.

(1.) Suppose we required to find the sum of the two numbers 38 and 45. Here $38=3$ tens$+8$ units, and $45=4$ tens$+5$ units. Now it is evident that 38 and 45 will be added together when we have added together the parts of which these numbers are composed; but they are composed of 3 tens$+4$ tens$=7$ tens, and 8 units$+5$ units$=13$ units; the sum is therefore 7 tens and 13 units. But 13 units$=1$ ten$+3$ units; and hence, 7 tens$+13$ units$=8$ tens$+3$ units, that is, 83. The same may be done more concisely by using the cipher instead of the word *ten*.

$$\text{Thus, } \left.\begin{aligned} 38+45 &= \overline{30+8}+\overline{40+5} \\ &= 30+40+8+5 \\ &= 70+13=70+10+3 \\ &= 83 \end{aligned}\right\} = \begin{array}{r} 38 \\ 45 \\ \hline 83 \end{array}$$

From this example we see that the tens and the units of the proposed numbers must be collected together separately.

(2.) Let it be required next to add together 3689 and 1634.

Here, $3689=3$ thous. 6 hund. 8 tens and 9 units.
$\qquad 1634=1$ thous. 6 hund. 3 tens and 4 units.

If, now, to each part of the first number we add each part of the second which is under it, we will evidently have added

together, as in the last case, the given numbers, 3689 and 1634; the sum required is therefore

4 thous. 12 hund. 11 tens and 13 units

But, 13 units = 1 ten and 3 units
11 tens = 1 hund. 1 ten
12 hund. = 1 thous. 2 hund.
4 thous. = 4 thous.

and adding the parts that are here again brought together, we get

$$3689+1634=5 \text{ thous. } 3 \text{ hund. } 2 \text{ tens and } 3 \text{ units}=5323.$$

The same process, using the signs and ciphers, is as follows:

$$\begin{array}{r} 3689=3000+600+80+9 \\ 1634=1000+600+30+4 \\ \hline 3689+1634=4000+1200+110+13 \end{array}$$

$$\begin{array}{lrrrr} \text{But,} & 13= & & & 10+3 \\ & 110= & & 100+ & 10 \\ & 1200= & 1000+ & 200 & \\ & 4000= & 4000 & & \end{array}$$

Therefore $3689+1634=5000+300+20+3=5323$.

Thus we learn that all the similar parts of the given numbers are to be added together separately; and that the significant figure on the left hand, when a denomination of the result has two (or more) such, is always to be added or *carried* to the next higher place, as every place of the final result, from the nature of our numeration scale, can only contain one figure; thus, the 1 ten of the 13 units (=1 ten+3 units) is to be added to the 11 tens, making 12 tens=1 hund.+2 tens; and the 1 hund. is to be added to the 12 hund., making 13 hund.=1 thous.+3 hund.; and finally, the 1 thous. is to be added to the 4 thous., making 5 thous.; making, as already stated,

5 thous.+3 hund.+2 tens+3 units; that is, 5323.

The following equations may be proved in the same way:—

$$24+37=61 \qquad 2834+2799=5633$$
$$49+78=127 \qquad 5678+4867=10545$$

(2.) The process being now thoroughly understood, we may translate the successive operations into the following rules:—

I. Write the numbers which are to be added together under one another (for convenience), so that the figures which express the units shall be all in one column, those which express tens all in another column, those which express hundreds in a third column, and so on.

II. Add together all the figures in the column of units, and if the sum does not exceed 9, write it beneath; but if it exceeds 9, separate it into units and tens, and write down the units under the unit column, and keep the number of tens in memory (or write down their number under the column of tens).

III. Regard the tens obtained by the addition of the unit column as units of the column of tens, and find the sum of that column with this addition. If the number does not exceed 9, write it beneath the column, but if it exceeds 9 separate it into units of tens and tens of tens—that is, into tens and hundreds (which may be regarded as units and tens, exactly as before); then write the number of tens beneath the column of tens, and reserve the hundreds to be added to the next column—that is, the column of hundreds.

IV. Proceed exactly in the same way through every column, setting down always the right-hand figure of the sum obtained, and carrying all the figures on the left of it to the next higher column, till having arrived at the last column, write down the whole sum found by adding its figures and the figures (if any) which required to be carried from the preceding column.

Let it be required to find the sum of—

$$7658+9684+786+196+3060+5196.$$

We shall here write down the numbers on the left as the rule requires, and on the right in detail, so that the identity of the methods may be as obvious as possible.

By Rule.		In Detail.
7658		7 thous. 6 hund. 5 tens 8 units
9684		9 thous. 6 hund. 8 tens 4 units
786	=	7 hund. 8 tens 6 units
196		1 hund. 9 tens 6 units
3060		3 thous. 0 hund. 6 tens 0 units
5196		5 thous. 1 hund. 9 tens 6 units
Sum, 26580	=	26 thous. 5 hund. 8 tens 0 units

The calculation is gone through as follows:—

Units $=6+0+6+6+4+8=30$ units $=3$ tens $+0$ units
Write down the 0, and carry the 3.
Tens $=3+9+6+9+8+8+5=48$ tens $=4$ hund. $+8$ tens
Write down the 8, and carry the 4.
Hund. $=4+1+0+1+7+6+6=25$ hund. $=2$ thous. $+5$ hund.
Write down the 5, and carry the 2.
Thous. $=2+5+3+9+7=26$ thous.; which write down.

In practice it is, of course, unnecessary to attend to ciphers when they stand in the columns. We have here written them in the work merely to avoid any difficulty which might possibly arise by their omission. There are several methods of proving the accuracy of such results; but the simplest, and therefore the best, is to make the addition twice, beginning at the bottom of the columns, and adding upwards the first time; and at the top, and adding downwards the next: if the sum obtained is the same in both cases, it may be considered, in all probability, correct.

The student may now examine whether the following additions be correctly made:—

$$5783+4318+5987+8527=24615$$
$$77756+3388+9763+90257=181164$$
$$10376786+789632+589+73=11167080$$
$$5784200+200003+549830+14378539=20912572$$

It will afford some further exercise to prove that the sum of the numbers, in every row of the following table, whether reckoned upright, or from right to left, or from corner to corner, is 24156.

2016	4212	1656	3852	1296	3492	936	3132	576	2772	216
252	2052	4248	1692	3888	1332	3528	972	3168	612	2412
2448	288	2088	4284	1728	3924	1368	3564	1008	2808	648
684	2484	324	2124	4320	1764	3960	1404	3204	1044	2844
2880	720	2520	360	2160	4356	1800	3600	1440	3240	1080
1116	2916	756	2556	396	2196	3996	1836	3636	1476	3276
3312	1152	2952	792	2592	36	2232	4032	1872	3672	1512
1548	3348	1188	2988	432	2628	72	2268	4068	1908	3708
3744	1584	3384	828	3024	468	2664	108	2304	4104	1944
1980	3780	1224	3420	864	3060	504	2700	144	2340	4140
4176	1620	3816	1260	3456	900	3096	540	2736	180	2376

(3.) It is sometimes necessary to add very long columns of figures amid interruptions, and considerable annoyance is often experienced by our forgetting the carriage figure, and having in consequence to begin the addition anew. Under these circumstances it is advisable to begin the addition at the left, and *write* always the right-hand figure of each individual sum under its respective column, and the carriage figure a place to the left. This will give the sum of the columns in two lines, which, when added together, will be the sum sought. The example annexed

$$\begin{array}{r} 536789 \\ 436121 \\ 317600 \\ 134674 \\ 236789 \\ 234251 \\ 321446 \\ \hline 2084340 \\ 13333 \\ \hline 2217670 \end{array}$$

will make this plain, if the principle of addition itself be rightly understood. The same artifice might be adopted, beginning at the units column; but that, on trial, will be found less convenient.

II. SUBTRACTION.

We have already stated, as a principle to be borne in mind, that (1) the difference between two numbers is not altered by increasing or diminishing each of the numbers by the same number. For instance, the numerical difference of two armies will remain the same although each should be reinforced by 1000 men, and it will not be affected by withdrawing 1000 from each. We may also lay it down as an axiom, that (2) the difference between two numbers is made up of the sum of the differences between the parts of which those numbers are composed.

Thus, 9 exceeds 7 by 2,
and 4 exceeds 3 by 1,
and 8 exceeds 5 by 3.
Therefore $9+4+8=21$ exceeds $7+3+5=15$ by $2+1+3=6$.

If these principles be understood there will be no difficulty in working subtraction. To take an example—

(1.) Let it be required to subtract 6835 from 8976.

Here 8976 = 8 thous. 9 hund. 7 tens and 6 units.
6835 = 6 thous. 8 hund. 3 tens and 5 units.

Now 6 *units* exceed 5 *units* by 1 *unit*,
7 *tens* exceed 3 *tens* by 4 *tens*,
9 *hund.* exceed 8 *hund.* by 1 *hund.*
8 *thous.* exceed 6 *thous.* by 2 *thous.*

Therefore 8 thous. 9 hund. 7 tens and 6 units = 8976
exceed 6 thous. 8 hund. 3 tens and 5 units = 6835

by 2 thous. 1 hund. 4 tens and 1 unit = 2141

that is, 8976 exceeds 6835 by 2141,
or, 6835 subtracted from 8976 leaves 2141,
or $8976-6835=2141$, as required.

The above question is answered by applying only the second of the foregoing principles: we shall now take a case where it will be necessary to apply both.

(2.) Subtract 19786 from 31814; *i.e.* find $31814-19786$.

These numbers written in detail as before are—

3 ten-thous. 1 thous. 8 hund. 1 ten and 4 units,
1 ten-thous. 9 thous. 7 hund. 8 tens and 6 units.

Here we at once perceive that we cannot proceed as in the last example, for 6 units are more than 4 units, and 8 tens than 1 ten, and further on we find 9 thous. standing beneath 1 thous. But recollecting that we may add the same number to *both* of the given numbers, without altering their difference (and the difference is that which we are in quest of), we proceed to apply the principle in this manner—add ten to the 4 units of the upper line, making 14 units, and one to the 8 tens of the under line, making 9 tens; so that the numbers will now read—

3 ten-thous. 1 thous. 8 hund. 1 ten and 14 *units*,
1 ten-thous. 9 thous. 7 hund. 9 *tens* and 6 units.

Again, add 1 hund. = 10 tens to the 1 ten in the upper line, making 11 tens, and 1 hund. to the 7 hund. of the under line, making 8 hund.; so that now the numbers will read—

3 ten-thous. 1 thous. 8 hund. 11 *tens* and 14 *units*,
1 ten-thous. 9 thous. 8 *hund.* 9 *tens* and 6 units.

Lastly, add 1 ten-thous. = 10 thous. to the 1 thous. of the upper line, making 11 thous., and 1 ten-thous. to the 1 ten-thous. of the under line, making 2 ten-thous.; so that the number will read—

3 ten-thous. 11 *thous.* 8 hund. 11 *tens* and 14 *units*.
2 *ten-thous.* 9 thous. 8 *hund.* 9 *tens* and 6 units.

Now, these numbers are not the same as those given; but we know that their difference must be the same, since we have made exactly the same additions to each; and by subtracting the one from the other, as we did in the first example, we get, as the difference sought,

1 ten-thous. 2 thous. 0 hund. 2 tens and 8 units = 12028.

Therefore $31814-19786=12028$, and the proof is, that $19786+12028=31814$, which, however, is stated in two parts.

We may now embody these processes in a rule, as follows:—

I. Write the number which is to be subtracted (which is of course always the less of the two, and is called the *subtrahend*), under the other (which is called the *minuend*), so that its units may fall under the units of the other, the tens under the tens, and so on.

II. Subtract each figure of the lower line from that above it, if that can be done. When that cannot be done add 10 to the upper figure, and then subtract the lower figure, but when that is done recollect to add 1 to the next figure in the lower line before subtracting it from its corresponding figure in the upper line.

Example.—Find $867543267-164567345=$?

Arrange the numbers as directed in part I. of the rule. Here $7-5=2$; $6-4=2$; $2-3$ is impossible, but $12-3=9$, and carry 1; then $3-(1+7)=3-8$ is again impossible, but $13-8=5$ and carry 1; $4-(1+6)=4-7$ is also impossible, but $14-7=7$ and carry 1; $5-(1+5)=5-6$ is also impossible, but $15-6=9$ and carry 1; $7-(1+4)=2$; $6-6=0$; and $8-1=7$.

Minuend = 867543267
Subtrahend = 164567345

Remainder = 702975922

The work is readily proved by adding together the remainder and subtrahend; the sum of course should be the minuend.

There are, however, really these two simple methods of ascertaining the correctness of a subtraction sum—

1. Add the difference found to the subtrahend, and if correct the result will equal the minuend.

2. Subtract the difference from the minuend, and if correct the result will equal the subtrahend; for example,

The Authorized Version of the Old Testament contains 592,439 words, and the New Testament 181,253; how many more are there in the former that in the latter?

Working.	Proof (1).	Proof (2).
592,439	181,253 subtrahend	592,439 minuend.
181,253	411,186 difference	411,186 difference.
411,186	592,439 minuend	181,253 subtrahend.

The following instances may now be verified for the sake of exercise:—

33758317658	8756789675436
21869433245	7900976080978
11888884413	855813594458

Should there not be as many figures in the under line as there are in the upper one, the deficiency may be *actually* made up with ciphers; but it saves trouble to proceed without writing them, simply bearing in mind that the line may be so extended. This direction is founded on the self-evident fact that a number is not altered in value by placing ciphers on the left of it. Thus, 321 is the same as 00321, for it means 3 hundreds 2 tens and 1 unit, and 00321 means in reality nothing more; for 0 ten-thousands, 0 thousands, 3 hundreds, 2 tens, and 1 unit, merely differs in saying that the number contains no tens of thousands and no thousands.

It would be very different, however, were the ciphers placed on the right; for then the 3 would become tens of thousands, the 2 would be thousands, and the 1 would mean a hundred, and the ciphers would denote that there were no tens or units. The following are instances in which these remarks are applicable:—

8360000	1842007	30000680
6756	90009	9091
8353244	1751998	29991589

When two or more numbers are given to be subtracted from two or more other numbers, it is *generally* best to add together (1) all those belonging to the minuend, (2) all those belonging to the subtrahend, and (3) to take the sum of the one set from the sum of the other ; thus—

From $675+70+1211+673$, subtract $31+910+76+106+78$.

Here, $675+70+1211+673=2629$; and $31+910+76+106+78=1201$.

Then, $2629-1201=1428$.

Find the difference between $6173+95+78$, and $867+712+81$. *Answer*, 4686.

What is $2572-183+17856-1273+534$? *Answer*, 19506.

(3.) There is an expeditious and elegant mode of subtracting numbers by means of what is called the *arithmetical complement*. It is not taken notice of in elementary treatises on arithmetic, because it requires the learner to know something about the principle before he can practise it with success, and this is reckoned superfluous in the mere *art of ciphering*. We shall try to make it plain.

Let it be required to find $1000-732$. The answer, by the common rule, is 268 ; but we shall obtain exactly the same result by subtracting the units from 10, and the other figures successively from 9.

Thus, $10-2=8$; $9-3=6$; and $9-7=2$.

We may therefore state it as a rule, that to *subtract a number from* 1, *followed by as many ciphers as the number has figures, the figure in the unit's place must be subtracted from* 10, *and the others from* 9.

Thus, $1000000-708367=291633$.

This process, which is so easy that it scarcely deserves to be counted an operation, is made use of for our purpose in the following manner :—

Let the difference $3487-259$ be required.

It is here evident that by decomposing 3487 into $2487+1000$, the difference between it and 259 is not altered, and we shall have

$2487+1000-259$; but $1000-259=741$.

Therefore, $2487+1000-259=2487+741=3228$.

Thus, instead of subtracting 259, we have, in fact, added 741 ; and all cases of subtraction may be reduced to cases of addition in the same way. The following subtractions may be made by this mode, and then we shall show how the rule may be somewhat shortened.

$1660-786=874$ $\qquad$ $4686-996=3690$.

All that is necessary to the shortening of the process, is the admission of this principle : *the difference between two numbers is not altered by adding a number to it, if at the same time we subtract the same number from it.* Let this number always be 1, followed by as many ciphers as the number to be subtracted has figures.

Thus, suppose it is required to work the sum $9846-635$.

Here, by adding 1000 and subtracting 1000, we get

$9846+1000-635-1000$.

But, by performing the operation $1000-635$, we get

$9846+365-1000$.

Now, all that remains to be done is to add 365 to 9846, and to subtract 1 from the thousands of the result ; but we might put the 365 in place of the ciphers in 1000, provided we put some mark upon the 1 to show that while the other figures are to be added, this one is to be subtracted. This is done by placing a dash, answering to the sign of subtraction, over the 1, making it $\bar{1}$, and making $365-1000$ into $\bar{1}365$. This artifice will convert the above expression into

$9846+\bar{1}365=9211$

a calculation which is otherwise shown in the margin.

$$\begin{array}{r} 9846 \\ \bar{1}365 \\ \hline 9211 \end{array}$$

The quantity $\bar{1}365$, is what is called the *arithmetical complement* of 635 ; and generally to find the arithmetical complement of any number, we must subtract the units figure from 10, the others from 9, and place $\bar{1}$ on the left of the result. It will also be observed, that *this complement, added to the number, gives* 0 *for the sum.* Thus $635+\bar{1}365=0000=0$. Further, in *every case where it is required to subtract a number we may add its arithmetical complement.*

As we can readily perform such subtractions as $1000-635$ mentally, in fact, as quickly as we can write the figures, the arithmetical complement furnishes us with a very neat and expeditious way of taking the balance of a successive set of additions and subtractions. For instance—

$32731+5729-371-4834$,

takes the form shown in the margin ; the complement of 371 being $\bar{1}629$, and that of 4834 being $\bar{1}5166$; the $\bar{1}$'s in the columns must of course be subtracted as before shown.

$$\begin{array}{r} 32731 \\ 5729 \\ \bar{1}629 \\ \bar{1}5166 \\ \hline 33255 \end{array}$$

Presuming that the preceding principles are well understood, we may now show how sufficient exercise upon them may be obtained. Take a series of numbers, each containing one figure more than the preceding one ; say 271, 3567, 46891, 506798, 9763897, and 85438796 ; and subtract each preceding number from that which follows it—

3567	46891	506798	9763897	85438796
271	3567	46891	506798	9763897
3296	43324	459907	9257099	75674899

Let the learner then add all his results together, with the least number chosen, and, if his work be correct, the final result will be the greatest number. The completion of the operation is shown beneath—

$$\begin{array}{rr} \text{Differences} = & \left\{\begin{array}{r} 75674899 \\ 9257099 \\ 459907 \\ 43324 \\ 3296 \end{array}\right. \\ \text{Least number} = & 271 \\ \hline \text{Greatest number} = & 85438796 \end{array}$$

THE LATIN LANGUAGE.—CHAPTER III.

ACCIDENCE—THE ADJECTIVE.

As adjectives express the nature or quality of nouns, they have, to make this connection the more apparent, their terminations similar : hence they require to be in the same *case* and *number* as the nouns which they qualify. On this account they are provided with the same number and kind of *cases*, both singular and plural. They must also agree with their nouns in *gender* as well as in *case* and *number*. Thus in the combination, *bonus puer*, a good boy, *puer*, the noun, being masculine, *bonus* must be the same, and in all its cases it will be declined like *dominus ;* but when the noun is feminine, as in *bona puella*, a good girl, *bonus* is changed into *bona*, which is declined throughout like *rosa*. So when the noun is neuter, as in *bonum opus*, a good work, *bonus* becomes *bonum*, and is then declined like *donum*.

Adjectives are either (1) of the First and Second Declensions, or (2) of the Third only.

Adjectives of three terminations, with the exception of those given under II. 3, correspond to the masculine, feminine, and neuter terminations of the First and Second Declensions of nouns; but adjectives of one or two terminations correspond to those of the Third Declension, the former comprising the masculine and feminine, the latter the neuter. No adjectives take the case-endings of the Fourth or Fifth Declensions.

I. Adjectives of the First and Second Declensions have the following three forms :—(1) *us, a, um ;* (2) *er, ra, rum ;* and (3) *ĕr, ĕra, ĕrum.*

(1.) Adjectives in *us, a, um*, are declined like *servus, rosa,* and *donum.*

EXAMPLE—*Bonus, bona, bonum.*

	Singular.				*Plural.*		
	m.	*f.*	*n.*		*m.*	*f.*	*n.*
Nom.	Bŏn-us,	a,	um.	*Nom.*	Bon-i,	æ,	a.
Gen.	Bon-i,	æ,	i.	*Gen.*	Bon-ōrum,	ārum,	ōrum.
Dat.	Bon-o.	æ,	o.	*Dat.*	Bon-is,	is,	is.
Acc.	Bon-um,	am,	um.	*Acc.*	Bon-os,	as,	a.
Voc.	Bon-e,	a,	um.	*Voc.*	Bon-i,	æ,	a.
Abl.	Bon-o,	a,	o.	*Abl.*	Bon-is,	is,	is.

Decline like *Bonus*:—

Alt-us,	a,	um,	*high.*	Magn-us,	a,	um,	*great.*
Car-us,	a,	um,	*dear.*	Măl-us,	a,	um,	*bad.*
Doct-us,	a,	um,	*learned.*	Nov-us,	a,	um,	*new*
Dŭbĭ-us,	a,	um,	*doubtful.*	Pallĭd-us,	a,	um,	*pale.*
Dur-us,	a,	um,	*hard.*	Parv-us,	a,	um,	*little.*
Fēcund-us,	a,	um,	*fruitful.*	Pi-us,	a,	um,	*pious.*
Læt-us,	a,	um,	*joyful.*	Sanct-us,	a,	um,	*holy.*
Lat-us,	a,	um,	*broad.*	Sobri-us,	a,	um,	*sober.*
Long-us,	a,	um,	*long.*	Ver-us,	a,	um,	*true.*

The following adjectives in *us* take *ius* in the genitive, and *i* in the dative singular, but in all other parts are declined like *bonus*:—*Alius, alia, aliud,* another, *i.e.* a different one (of many), *nullus,* none, *solus,* alone, *totus,* whole, *ullus,* any, *unus,* one.

Unus has no *plural* number, unless it be joined to a noun which has *no singular* number; as, *unæ litteræ,* a letter, *una mœnia,* a wall.

EXAMPLE—*Totus, tota, totum.*

	Singular.				*Plural.*		
	m.	*f.*	*n.*		*m.*	*f.*	*n.*
Nom.	Tōt-ŭs,	a,	um.	*Nom.*	Tot-i,	æ,	a.
Gen.	Tot-īŭs,	īŭs,	īŭs.	*Gen.*	Tot-ōrum,	ārum,	ōrum.
Dat.	To-tī,	ī,	ī.	*Dat.*	Tot-is,	is,	is.
Acc.	Tot-um,	am,	um.	*Acc.*	Tot-os,	as,	a.
Voc.	Tot-e,	a,	um.	*Voc.*	Tot-i,	æ,	a.
Abl.	Tot-o,	a,	o.	*Abl.*	Tot-is,	is,	is.

Besides these *vĕtus,* old, and *plus,* more, are the only adjectives ending in *us* which are not declined like *bonus;* they have only one termination. *Vĕtĕr* is found for *vĕtŭs* in old authors.

EXAMPLE—*Alter, altera, alterum.*

	Singular.				*Plural.*		
	m.	*f.*	*n.*		*m.*	*f.*	*n.*
Nom.	Altĕr,	ă,	um.	*Nom.*	Altĕr-ī,	æ,	ă.
Gen.	Altĕr-īŭs,	īŭs,	īŭs.	*Gen.*	Altĕr-ōrum,	ārum,	ōrum
Dat.	Altĕr-ī,	ī,	ī,	*Dat.*	Altĕr-īs,	īs,	īs.
Acc.	Altĕr-um,	am,	um.	*Acc.*	Altĕr-ōs,	ās,	ă.
Voc.	Altĕr,	ă,	um.	*Voc.*	Altĕr-ī,	æ,	ă.
Abl.	Altĕr-ō,	ā,	ō.	*Abl.*	Altĕr-īs,	īs,	īs.

EXAMPLE—*Uter, utra, utrum.*

	Singular.				*Plural.*		
	m.	*f.*	*n.*		*m.*	*f.*	*n.*
Nom.	Utĕr,	ă,	um.	*Nom.*	Utr-i,	æ,	ă.
Gen.	Utr-īŭs,	īŭs,	īŭs.	*Gen.*	Utr-ōrum,	ārum,	ōrum
Dat.	Utr-ī,	ī,	ī.	*Dat.*	Utr-īs,	īs,	īs.
Acc.	Utr-um,	am,	um.	*Acc.*	Utr-ōs,	ās,	ă.
Voc.	Utĕr,	ă,	um.	*Voc.*	Utr-ī,	æ,	ă.
Abl.	Utr-ō,	ā,	ō.	*Abl.*	Utr-īs,	īs,	īs.

Neuter, neither, *utercumque,* whichever of the two, *uterlĭbet,* which of the two you please, *uterque,* both, *utervis,* which of the two you please.

The suffixes *quĕ, vīs, lĭbĕt, cumquĕ,* are appended to each case-form; as *ŭtrĭusquĕ, ŭtrīvīs, utrōlĭbĕt, ŭtrumcumquĕ.*

Altĕrŭtĕr, one or the other, is usually declined as *ŭtĕr;* but the Gen. *altĕrĭŭs-ŭtrĭŭs* is found.

The *i* of the genitive is, in prose, always *long,* in verse sometimes *short.*

(2) Adjectives in *er, ra, rum,* are declined like *puer, rosa,* and *donum.*

EXAMPLE—*Tener, tenera, tenerum.*

	Singular.				*Plural.*		
	m.	*f.*	*n.*		*m.*	*f.*	*n.*
Nom.	Tĕner,	a,	um.	*Nom.*	Tenĕr-i,	æ,	a.
Gen.	Tenĕr-i,	æ,	i.	*Gen.*	Tener-ōrum,	ārum,	ōrum.
Dat.	Tener-o,	æ,	o.	*Dat.*	Tener-is,	is,	is.
Acc.	Tener-um,	am,	um.	*Acc.*	Tener-os,	as,	a.
Voc.	Tener,	a,	um.	*Voc.*	Tener-i,	æ,	a.
Abl.	Tener-o,	a,	o.	*Abl.*	Tener-is,	is,	is.

Tener is shortened from *tenerus.*

Only the following adjectives are declined on this model—*Asper,* rough, *gibber,* hunch-backed, *lacer,* torn, *liber,* free *miser,* wretched, *prosper,* prosperous, *satur,* full (fed).

Decline similarly all the compounds of *gero* and *fero,* as *armiger,* weapon-bearing, *corniger,* horned, *frugifer,* fruitful, *laniger,* wool-bearing, *lucifer,* light-bringing, *opifer,* bringing help.

Dexter, on the right hand, propitious, is declined either as *tener* or *ater.*

(3) Adjectives in *er, era, erum,* are declined like *liber, rosa,* and *donum.*

EXAMPLE—*Ater, atra, atrum.*

	Singular.				*Plural.*		
	m.	*f.*	*n.*		*m.*	*f.*	*n.*
Nom.	Ater,	a,	um.	*Nom.*	Atr-i,	æ,	a.
Gen.	Atr-i,	æ,	i.	*Gen.*	Atr-orum,	arum,	orum.
Dat.	Atr-o,	æ,	o,	*Dat.*	Atr-is,	is,	is.
Acc.	Atr-um,	am,	um.	*Acc.*	Atr-os,	as.	a.
Voc.	Ater,	a,	um.	*Voc.*	Atr-i,	æ,	a.
Abl.	Atr-o,	a,	o.	*Abl.*	Atr-is,	is.	is.

Decline in a similar manner.

Æg-er,	ra,	rum,	*sick.*	Pulch-er,	ra,	rum,	*fair.*
Creb-er,	ra,	rum,	*frequent.*	Rub-er,	ra,	rum,	*red.*
Mac-er,	ra,	rum,	*lean, thin.*	Vaf-er,	ra,	rum.	*crafty.*
Nig-er,	ra,	rum,	*black.*	Sinist-er,	ra,	rum,	*left (side.)*

II. To the Third Declension belong—(1) Adjectives in *x* or *ns,* of *one termination;* (2) those in *is, is, e,* of *two terminations;* (3) and a few in *er* or *ris, ris, re,* of *three terminations.*

1.—*Of one Termination.*

EXAMPLE—Felix, *happy.*

	Singular.		*Plural.*
Nom.	Felix (*m. f. n.*)	*Nom.*	Felic-es (*m.f.*), Felic-ia (*n.*)
Gen.	Felic-is, } *for the three*	*Gen.*	Felic-ium, } *for the three*
Dat.	Felic-i, } *genders.*	*Dat.*	Felic-ibus, } *genders.*
Acc.	Felic-em (*m. f.*), Felix (*n.*)	*Acc.*	Felic-es (*m. f.*), Felic-ia.
Voc.	Felix.	*Voc.*	Felic-es (*m. f.*), Felic-ia.
Abl.	Felic-i *or* Felic-e (*m. f. n.*)	*Abl.*	Felic-ibus (*m. f. n.*)

EXAMPLE—Ingens, *great.*

	Singular.		*Plural.*
Nom.	Ingens (*m. f. n.*)	*Nom.*	Ingent-es (*m. f.*), ingentia
Gen.	Ingent-is, } *for the three*	*Gen.*	Ingent-um, } *for thethree*
Dat.	Ingent-i, } *genders.*	*Dat.*	Ingent-ibus, } *genders.*
Acc.	Ingent-em (*m. f.*), ingens.	*Acc.*	Ingent-es (*m. f.*), ingentia.
Voc.	Ingens.	*Voc.*	Ingent-es (*m. f.*), ingentia
Abl.	Ingent-i or ĕ (*m. f. n.*)	*Abl.*	Ingent-ibus (*m. f. n.*)

Decline in the same manner—

Amans,	tis,	*loving.*	Ferox,	ōcis,	*fierce.*
Atrox,	cis,	*cruel.*	Loquax,	cis,	*talkative.*
Audax,	cis,	*bold,*	Prudens,	tis,	*prudent.*
Clemens,	tis,	*gentle.*	Recens,	tis,	*fresh.*
Elĕgans,	tis,	*elegant.*	Sapiens,	tis,	*discreet.*

2.—*Of Two Terminations.*

EXAMPLE—*Fortis, e,* brave.

	Singular.			*Plural.*	
	m. & f.	*n.*		*m. & f.*	*n.*
Nom.	Fort-is,	e.	*Nom.*	Fort-es,	ia.
Gen.	Fort-is,	is.	*Gen.*	Fort-ium,	ium.
Dat.	Fort-i,	i.	*Dat.*	Fort-ibus,	ibus.
Acc.	Fort-em,	e.	*Acc.*	Fort-es,	ia.
Voc.	Fort-is,	e.	*Voc.*	Fort-es,	ia.
Abl.	Fort-i,	i.	*Abl.*	Fort-ibus,	ibus.

Decline in the same manner—

Com-is,	e,	*affable.*	Simil-is,	e,	*similar.*
Dulc-is,	e,	*sweet.*	Steril-is,	e,	*sterile.*
Lev-is,	e,	*light.*	Trist-is,	e,	*sad.*
Omn-is,	e,	*all, every.*	Util-is,	e,	*useful.*

To these add *dis* (m. & f.), *dit-e* (n.), rich, gen. *dit-is,* which is a contracted form of *dives, di-vi-tis,* and is used in all its cases, except the nominative and vocative singular masculine and feminine.

Exception.—*Juven-is,* young, has no neuter, and is declined like *sermo.*

3.—*Of Three Terminations.*

Adjectives in *er* or *ris, ris, re,* are declined like *fortis,* with this exception that in the *nominative* and *vocative masculine singular* they have the second termination *er,* as well as *ris.* They are thus declined—

EXAMPLE—*Acer* or *acris, acre,* sharp.

	Singular. m. & f.	n.		*Plural.* m. & f.	n.
Nom.	Ac-er *or* ris,	re,	*Nom.*	Ac-res,	ria.
Gen.	Ac-ris,	ris.	*Gen.*	Ac-rium,	rium.
Dat.	Ac-ri,	ri.	*Dat.*	Ac-ribus,	ribus.
Acc	Ac-rem,	re.	*Acc.*	Ac-res,	ria.
Voc.	Ac-er *or* ris,	re.	*Voc.*	Ac-res,	ria.
Abl.	Ac-ri,	ri.	*Abl.*	Ac-ribus,	ribus.

Decline in the same manner—

Alac-er,	ris, re, *cheerful, brisk.*	Pedest-er,	ris, re, *pedestrian.*
Campest-er,	ris, re, *rural.*	Put-er,	ris, re, *rotten.*
Celeb-er,	ris, re, *famous.*	Salub-er,	ris, re, *wholesome.*
Cel-er,	is, e, *swift* (*G. P. um*).	Silvest-er,	ris, re, *woody.*
Equest-er,	ris, re, *equestrian.*	Terrest-er,	ris, re, *terrestrial.*
Palust-er,	ris, re, *marshy.*	Voluc-er,	ris, re, *swift.*

They may be concisely exhibited in this form, viz.—

Alac-	Pedest-	er (ris),	ris,	re,	res,	res,	ria.
Campest-	Put-	ris,	ris,	ris,	rium,	rium,	rium.
Celeb-	Salub-	ri,	ri,	ri,	ribus,	ribus,	ribus.
Cel-	Silvest-	rem,	rem,	re,	res,	res,	ria.
Equest-	Terrest-	er (ris),	ris,	re,	res,	res,	ria.
Palust-	Voluc-	ri,	ri,	ri,	ribus,	ribus,	ribus.

Add to these the names of months in *er,* which are generally adjectives, as *September, October,* &c.

NOTES.

1. Adjectives of *one termination* have *i* more frequently than *e* in the ablative singular. Some have only *i,* as *memor, is,* mindful; *par, is,* equal; *anc-eps, ipitis,* doubtful; *præc-eps, ipitis,* headlong; *ingen-s, tis,* huge; *iner-s, tis,* unskilful; *recen-s, tis,* recent; *repen-s, tis,* sudden; and the phrase *præsenti tempore,* at the present time.

However, they mostly take *e* when used as nouns, especially those in *ns* and in *x.* Add *consors,* partner; *vigil,* watchful; and the present participles.

2. The following adjectives have *e* in the ablative singular and *um* in the genitive plural. Except *hosp-es,* which has *hospita,* they have no neuter plural:—

Des-es,	idis,	*inactive.*	Res-es,	idis,	*sluggish.*
Hosp-es,	itis,	*stranger.*	Sen-ex,	is,	*old.*
Pauper,	is,	*poor.*	Sosp-es,	itis,	*safe.*
Princ-eps,	ipis,	*first.*	Superst-es,	itis,	*surviving.*

The following adjectives have also *um* in the genitive plural:—

Cicur,	is,	*tame.*	Memor,	is,	*mindful.*
Compo-s,	tis,	*master of.*	Suppl-ex,	icis,	*suppliant.*
Div-es,	itis,	*rich.*	Uber,	is,	*copious.*
Immemor,	is,	*unmindful.*	Vet-us,	eris,	*old.*
Impo-s,	tis,	*not master of.*	Vigil,	is,	*watchful.*

Such adjectives as have *um* in the genitive plural come from nouns which have that termination in their genitive plural, as *degĕner, is* (*genus*), degenerate; *quadrupe-s, dis* (*pes*), four-footed; *bicorpor, is* (*corpus*), having two bodies; *inop-s, is* (*ops, opis*), indigent. Genitive plural, *degĕner-um,* &c. The neuter plural of these adjectives is seldom used; *vetus,* however, has *vetera.*

3. *Nequam,* worthless, and *frugi,* honest (properly the dative of *frux*), are indeclinable.

4. Some adjectives of one termination are joined with neuter substantives only in particular cases—*tricuspide telo,* ablative; but not *telum tricuspis,* nominative; because a neuter substantive may end, in the ablative, in *e;* but none end, in the nominative, in *is.* This, however, is a nicety which much reading and full knowledge alone supply the means of observing.

5. Some verbals in *x* are joined to neuter as well as feminine nouns, but not to masculine ones, as *ultrice flagello, victricibus armis*

6. The ablative singular of adjectives of one or two terminations generally ends in *i,* as *tristis, tristi,* except the following, which end in *e*:—

Bicorpor,	*double-bodied.*	Multipes,	*many-footed.*
Bipes,	*double-footed.*	Pauper,	*poor.*
Compos,	*in possession* (*of his*) *senses.*	Puber,	*adult.*
		Senex,	*old.*
Hospes,	*host or guest.*	Sospes,	*safe.*
Impos,	*powerless.*	Superstes,	*surviving.*

But (1) adjectives of one termination (as *felix*) have both *e* and *i* in the ablative, but *i* is more usual; and comparatives (as *melior*), but *e* is more usual; though in poetry *felice* and *meliore* are common. Horace uses *meliore.*

(2) The ablatives of participles, when not used adjectively (or as mere epithets, but as denoting a fact or circumstance), derived from nominatives in *ans* and *ens,* end in *te,* not *ti* (thus *nocte sequente* means — the night coming on; but *sequenti nocte* is—the following night), as *imperante Augusto,* not *imperanti.* Horace, it is said, never forms this participle in *ti.*

It will be found of great use to learn to classify adjectives according to their terminations, many of which have some similarity of signification indicated thereby, and most of which are similar in pronunciation and prosody. By grouping them together in such clusters we knit the ties of association round them, and increase the tenacity of the grasp of the memory upon them. We subjoin a few of such related classes. They fall naturally into two sets, viz.—

(1) Adjectives of the *First* and *Second Declensions,* which end in

āceus and *ĕus,* denoting a material, as *laneus,* woollen; *æreus,* brazen; *roseus,* rosy; *saxeus,* stony; *aureus,* golden; *marmoreus,* marble; *testaceus,* shelly.

ānus, (*a*) of the nature of, belonging to, as *humanus; montanus,* hilly; *Cæsarianus;* (*b*) denoting the legion, as *primanus,* of the first legion.

ārius, (*a*) having the character of, belonging to, as *contrarius, agrarius;* (*b*) holding so much, as *sextarius,* holding one-sixth, *vicesimarius,* holding one-twentieth.

āticus, fitted, characterized by, as *aquaticus, erraticus.*

ātus, ītus, ūtus, as *alātus,* winged; *oculātus,* eyed; *aurītus,* eared; *crinītus,* haired; *cornūtus,* horned; *astūtus,* astute.

entus, as *violentus,* violent; *gracilentus,* graceful; *luculentus,* transparent.

ēnus, as *plenus,* full; *terrenus,* consisting of earth.

ernus, as *hibernus,* wintry; *æternus,* eternal; *hodiernus,* to-day; *hesternus,* yesterday.

icius (from nouns in *is,* with *i* short), as *gentilĭcius,* national. or *itius* (from verbs and nouns in *us,* with *i* long), as *conductīcius,* rented; *novītius,* new; *multītius,* transparent.

ĭcus (from nouns), as *aulicus,* flute-like; *bellicus,* warlike; *civicus,* civic.

īcus (from verbs and adverbs), as *amicus,* friendly; *apricus* (*aperio*), open; *antiquus, anticus* (*ante*), antique.

ĭdus (from verbs), denoting bodily state or quality, as *frigidus,* cold; *algidus,* icy; *tepidus,* lukewarm; *humidus,* moist; *candidus,* white; *rapidus,* rapid; *cupidus,* desirous.

ĭmus, as *maritimus,* belonging to the sea; *finitimus,* neighbouring.

īnus, (*a*) denoting material, as *faginus,* beechen; *crystallinus,* crystalline; (*b*) denoting time, as *crastīnus, diutīnus, nundīnæ, hornotīnus, perendīnus, pristīnus, serotīnus,* all with short penult, except *matutīnus* and *vespertīnus;* (*c*) denoting quality, as *agninus,* lamblike; *caninus,* doglike.

ĭus, belonging to, as *regius,* royal; *patrius,* paternal.

īvus, having the nature of, as *æstivus, stativus, furtivus, nocivus.*

lus, diminutives; *parvulus,* rather little.

ōnus, as *patronus,* patronizing.

ōrius, as *oratorius,* oratorical; *motorius,* moving; *adulatorius,* adulatory.

ōsus, as *animosus,* courageous; *belluosus,* warlike; *ventosus,* windy; *saxosus,* stony; *morosus,* morose; *officiosus,* officious.

stus, as *nefastus,* unlawful; *funestus,* destructive; *onustus,* burdensome.

ūcus, as *caducus,* fading.

ŭlus (verbals), inclined to, as *bibulus,* drunken; *credulus,* credulous, *garrulus,* talkative.

undus, denoting bodily or mental feeling or faculty (from verbs), as *irācundus, fācundus* (from *for, fāri*), *furībundus, jūcundus.*

ūnus, as *opportunus,* opportune; *jejunus,* jejune.

urnus, as *diurnus,* daily; *nocturnus,* nightly.

(2) Adjectives of the *Third Declension*, which end in

ālis, as *regalis*, regal; *hospitalis*, kindly; *glacialis*, icy.
āris, as *popularis*, popular; *vulgaris*, vulgar; *salutaris*, salutary.
ātĭlis, as *aquatilis*.
ax, as *ferax*, fertile; *edax*, *-ācis*, eating (away).
ber, *bris*, *cer*, *cris*, as *salūber*, *salubris*, healthy; *ācer*, *acris*, sharp.
bĭlis (from verbs), capable of doing, being, &c., as *penetrabilis*, *delebilis*, *nōbilis*, *volūbilis*.
ēlis, as *crudelis*, cruel; *fidelis*, faithful.
ens, as *violens*, outrageous; *rubens*, blushing.
ensis, as *pratensis*, belonging to the meadow; *forensis*, legal.
es, as *locuples*, *-ētis*, rich.
ex, as *seminex*, *-ĕcis*, half.
īlis (from nouns), as *juvenilis*, *herilis*, *senilis*, *virilis*, *puerilis*.
ĭlis (from verbs), as *flexilis*, *pensilis*, *habilis*, *utilis*, *fissilis*, *rasilis*, *tonsilis*, *fragilis*, *coctilis*, *sculptilis*, *sectilis*, *facilis*.
ox, as *atrox*, bloody; *velox*, *-ōcis*, swift.
stris, as *palustris*, swampy; *sublustris*, glimmering.
ūlis, as *edulis*, eatable.

COMPARISON OF ADJECTIVES.

Adjectives have three degrees of Comparison.

1. The *Positive* denotes the possession of a quality *absolutely*, or in an ordinary degree, without any reference to *more* or *less*; as *doctus*, learned, *brevis*, short.

2. The *Comparative* expresses an *increase* or *extension* of the quantity or amount of the quality; as *doctior*, more learned, *brevior*, shorter or more short. The Comparative often signifies *excess* or *too much*; as *jactantior Ancus* (Virg.); or *rather*, as *sum paullo infirmior* (Hor.)

The *Comparative* of adjectives is formed from the first occurring case of the Positive ending in *i*, by adding *or* for the masculine and the feminine, and *us* for the neuter; the *Superlative* by adding *ssĭmus, a, um*; as—

Posit.			*Comp. m. f.*	*n.*	*Super. m.*	*f.*	*n.*
Doct-us,	i,		docti-or,	us;	docti-ssimus,	a,	um.
Fort-is,	is,	i,	forti-or,	us;	forti-ssimus,	a,	um.
Feli-x,	cis,	i,	felici-or,	us;	felici-ssimus,	a,	um.

The masculine and feminine in *or*, *oris*, is declined like *sermo*; the neuter in *us*, *oris*, like *corpus*; as—

Docti-or, or, us, *more learned*.

	Singular. *m.* and *f.*	*n.*		*Plural.* *m* and *f.*	*n.*
Nom.	Docti-or,	us.	*Nom.*	Doctior-es,	a.
Gen.	Doctior-is.	is.	*Gen.*	Doctior-um.	um.
Dat.	Doctior-i.	i.	*Dat.*	Doctior-ibus.	ibus.
Acc.	Docti-orem,	us.	*Acc.*	Doctior-es,	a.
Voc.	Docti-or,	us.	*Voc.*	Doctior-es,	a.
Abl.	Doctior-i	i or e.	*Abl.*	Doctior-ibus.	ibus

3. The *Superlative* increases or extends the signification to the greatest degree; as *doctissĭmus*, most learned, *brevissĭmus*, the shortest or most short. The Superlative often signifies *very much*; as *purissima mella*, very pure honey (Virg.) So *justissima tellus* (Virg.); *Optimus Virgilius* (Hor.)

The Superlative is declined like *bon-us, a, um*.

EXCEPTIONS.

1. Adjectives ending in *er*, *a*, *um*, and in *er*, *ris*, *re*, for the most part form their Superlative by adding *rĭmus, a, um*, to the nominative singular masculine, as—

Posit.		*Comp.*	*Super.*
Acer,	*sharp*,	acri-or,	acer-rimus.
Celer,	*swift*,	celeri-or,	celer-rimus.
Liber,	*free*,	liberi-or,	liber-rimus.
Miser,	*unfortunate*,	miseri-or,	miser-rimus.
Pauper,	*poor*,	pauperi-or,	pauper-rimus.
Pulcher,	*beautiful*,	pulchri-or,	pulcher-rimus.

Add to these *maturus*, *maturior*, *maturrimus*, ripe; *nuperus*, *nuperior*, *nuperrimus*, late; *vetus*, *veterior*, *veterrimus*, old; *deterior*, worse, *deterrimus*. *Dexter*, *ior*, has *dextimus*; *sinister*, *ior*, no superlative.

2. Those adjectives ending in *lis* change *is* into *lĭmus, a, um*, in the superlative, viz.:—

Agil-is,	*nimble*,	agili-or,	agil-limus,
Docil-is,	*docile*,	docili-or,	docil-limus,
Facil-is,	*easy*,	facili-or,	facil-limus.
Difficil-is,	*difficult*,	difficili-or,	difficil-limus.
Gracil-is,	*slender*,	gracili-or,	gracil-limus.
Humil-is,	*humble*,	humili-or,	humil-limus.
Simil-is,	*like*,	simili-or,	simil-limus.
Dissimil-is,	*unlike*,	dissimili-or,	dissimil-limus.

Some others are regular, as *util-is*, useful; super. *utilissimus*, &c. *Imbecill-is*, weak, has both *imbecillimus* and *imbecillissimus*. *Frugi* forms *frugalis*, which is regular.

3. Adjectives in *dĭcus*, *fĭcus*, *vŏlus*, change *us* into *entior*, *entissimus*, as *maledicus*, slanderous, comp. *maledic-entior*, super. *maledic-entissimus*; *malificus*, vicious, *malific-entior*, *malific-entissimus*; *benevolus*, kind, *benevol-entior*, *benevol-entissimus*. Also *egēnus*, needy; *egentior*, *egentissimus*.

4. Five adjectives are irregular, viz.:—

Posit.		*Comp.*	*Super.*
Bonus,	*good*;	melior, *better*;	optimus, *best*.
Malus,	*bad*;	pejor, *worse*;	pessimus, *worst*.
Magnus,	*great*;	major, *greater*;	maximus, *greatest*.
Parvus,	*little* (*small*);	minor, *less*;	minimus, *least*.
Multi,	*many*;	plures (ium), *more*;	plurimi, *most*.

5. Adjectives ending in *ĕus*, *ĭus*, *ŭus*, form their Comparative and Superlative by *magis*, more, and *maxime*, most; as *noxius*, noxious, *magis noxius*, *maxime noxius*; *idoneus*, fitting; *magis idoneus*, more fitting; *maxime idoneus*, most fitting. But adjectives in *quus* are regular, as *æquus*, *æquior*; *antiquus*, ancient, *antiquior*, *antiquissimus*. *Nequam* has *nequior*, *nequissimus*. *Assĭduior*; *egrĕgior*, *egrĕgiissimus*; *exĭguior*, *exĭguissimus*; *piissimus*, *perpĕtuissimus*, and *strēnuior* are also found.

6. Some Superlatives contract into a second form, as—

Posit.		*Comp.*	*Super.*
Exterus (extra),	*outside*;	exterior;	extremus, extimus.
Inferus (infra),	*beneath*;	inferior;	infimus, imus.
Superus (supra),	*above*;	superior;	supremus, summus.
Posterus (post),	*after*;	posterior,	postremus, postumus.

The Positives of these adjectives are little used except in the plural, and with a special meaning, as *posteri*, our descendants, posterity; *superi*, the gods above; *inferi*, the gods below.

7. Many adjectives admit of no comparison, as *văcuŭs*, *cănōrŭs*, *mĕdiocrĭs*, *claudŭs*, *mŏdĭcŭs*, *mĕrŭs*, *accommŏdŭs*, *mĕmŏr*, *dēgĕnĕr*, *perdīlĭgens*, *prædūrŭs*, *cornĭfĕr*, *clāvĭgĕr*, and others which experience will suggest.

8. Some proper names are found compared and used as adjectives; as *Nĕrōniŏr*, more cruel than Nero, *Pœniŏr*, more false than the Carthaginians. Similarly is formed *ipsissĭmŭs*, very self, &c.

The following table exhibits many of the irregular adjectives. Where a blank is left that degree is not used; the parenthesis shows that the word included is some other word not an adjective.

Posit.		*Comp.*	*Super.*
Adŏlescens,	*young*,	ădŏlescentiŏr.	
(Antē,	*before*),	antĕriŏr,	
Bellŭs,	*fine*,		bellissĭmŭs.
Bŏnŭs,	*good*,	mĕliŏr,	optĭmŭs.
(Citrā,	*within*),	cĭtĕriŏr,	cĭtĭmŭs.
Cīvīlis,	*civil*,	cīvīliŏr,	cīvīlissĭmŭs.
Consultŭs,	*skilled*,	consultiŏr,	consultissĭmŭs.
Dēsēs,	*slothful*,	dēsīdiŏr.	
(Deterus,	obsolete),	dētĕriŏr, *worse*,	dēterrĭmŭs.
Dextĕr,	*right*,	dextĕriŏr,	dextĭmŭs.
Dīversŭs,	*different*,		dīversissĭmŭs.
Dīvēs,	*rich*,	dītiŏr,	dītissĭmŭs.
Extĕrŭs,	*foreign*,	extĕriŏr,	extrēmŭs *or* extĭmŭs.
Falsŭs,	*false*,		falsissĭmŭs.
Fīdŭs,	*faithful*,		fīdissĭmŭs.
Flēbīlĭs,	*mournful*,	flēbīliŏr,	flēbīlissĭmŭs.
Inclȳtŭs,	*renowned*,		inclȳtissĭmŭs.
Infĕrŭs,	*beneath*,	infĕriŏr,	infĭmŭs *or* īmŭs.
Ingens,	*great*,	ingentiŏr,	ingentissĭmŭs.
(Intŭs,	*within*),	intĕriŏr,	intĭmŭs.
Invītŭs,	*unwilling*,		invītissĭmŭs.
Invictŭs,	*unconquered*,		invictissĭmŭs.
Jŭvĕnĭs,	*young*,	jūniŏr.	
Longinquŭs,	*distant*,	longinquiŏr.	
Magnŭs,	*great*,	mājŏr,	maxĭmŭs.
Mălŭs,	*bad*,	pējŏr,	pessĭmŭs.
Mātūrŭs,	*mature*,	mātūriŏr,	mātur-rĭmŭs *or* -issĭmŭs.

Posit.		Comp.	Super.
Multŭs,	*much*,	(plūs),	plūrĭmŭs.
Nēquam,	*wicked*,	nēquiŏr,	nēquissĭmŭs.
Nŏvŭs,	*new*,		nŏvissĭmŭs.
Nūpĕrŭs,	*recent*,	nūpĕrĭŏr,	nūperrĭmŭs.
(ὠκὺς,	*swift*),	ōcyŏr, *swifter*,	ōcissĭmŭs.
Opīmŭs,	*rich*,	ŏpīmiŏr.	
Parvŭs,	*little*,	mĭnŏr,	mĭnĭmŭs *or* parvissĭmŭs.
Postĕrŭs,	*late*,	postĕriŏr,	postrēmŭs *or* postŭmŭs.
(Prius,	*before*),	priŏr, *former*,	prīmŭs, *first*.
Proclīvĭs,	*steep*,	proclīviŏr,	proclīvissĭmŭs.
Prōnŭs,	*prone*,	prōniŏr,	prōnissĭmŭs.
(Prŏpĕ,	*near*),	prŏpiŏr,	proxĭmŭs.
Prŏpinquŭs,	*near*,	prŏpinquiŏr.	
Săcĕr,	*sacred*,		săcerrĭmŭs.
Sătĭs,	*enough*,	sătiŏr.	
Sătŭr,	*satisfied*,	sătŭriŏr,	săturrĭmŭs.
(Sĕcŭs,	*otherwise*),	sĕciŏr *or* sĕquiŏr.	
Sĕnex,	*old*,	sĕniŏr.	
Sĭnistĕr,	*left*,	sĭnistĕriŏr,	sĭnistĭmŭs.
Sŭpĕrŭs,	*above*,	sŭpĕriŏr,	supremŭs *or* summŭs.
(Ultrā,	*beyond*),	ŭltēriŏr,	ultĭmus.
Vĕtŭs,	*ancient*,	vĕtĕriŏr,	vĕterrĭmŭs.

Adjectives agree with the nouns they qualify in number, gender, and case; as

Sol splendidus, *the shining sun.*	Regina est pulchra, *the queen is beautiful.*
Luna splendida, *the shining moon.*	Reginæ sunt pulchræ.
Argentum splendidum, *the shining silver.*	Templum est opulentum, *the temple is magnificent.*
Miles est callidus, *the soldier is rash.*	Templa sunt opulenta.

The student is recommended to note the agreement of adjective and noun in the following examples, and to write out in full the agreeing words:—

Homines pii timent Deum,	*Holy men fear God.*
Ver jucundum delectat animum,	*A pleasant spring-time rejoices the mind.*
Probitas vera nobilitat hominem,	*True honesty ennobles a man.*
Modestia dulcis ornat feminam,	*Sweet modesty adorns a woman.*
Parva scintilla excitavit magnum incendium,	*A small spark has kindled a great fire.*

The meaning of a sentence sometimes overrides verbal rule; as *Capita conjurationis caesi sunt*, The heads of (*i.e.* the persons at the head of) the conspiracy were scourged; *Duo millia hostum capti sunt*, Two thousand of the enemy were captured.

A great number of adjectives, and participles used as adjectives, especially such as signify "full of"—*e.g.* desirous, studious, skilled or experienced in, sharing in, and likeness to, and their opposites, &c.—govern the genitive.

Avidus, *greedy.*	Gnarus, *knowing.*	Prudens, *knowing.*
Compos, *in possession.*	Memor, *mindful.*	Rudis, *uninformed.*
Conscius, *conscious.*	Particeps, *sharing.*	Similis, *like (inwardly).*
Consors, *participators.*	Patiens, *suffering.*	
Cupidus, *desirous.*	Peritus, *skilled.*	Socius, *allying.*
Expers, Exsors, *not sharing.*	Plenus, *full.*	Studiosus, *studious.*
	Potens, *powerful.*	

The following sentences illustrate this rule:—

Tempus, edax rerum,	*Time, the devourer of things.*
Rudis belli,	*Unskilled in war.*
Anxius potentiæ,	*Eager for power.*

To this class belong also (1) verbal adjectives in *ax*, *ns*, and *tus*; and (2) adjectives denoting affection, as desire and disdain, knowledge and ignorance, innocence and guilt.

Avĭdus gloriæ,	*Desirous of glory.*
Ignārus fraudis,	*Ignorant of fraud.*
Memor beneficiōrum,	*Mindful of favours.*
Mens sibi conscia recti,	*A mind conscious of its own integrity.*
Neque enim ignari sumus antè malorum,	*For neither are we aforetime unacquainted with misfortunes.*
Veterisque memor Saturnia belli,	*Juno mindful of an ancient contention.*
Homines nostræ consuetudinis imperiti,	*Men unskilled in our ways.*
Securus amorum germanæ,	*Safe in the love of her sister.*
Est natura hominum novitatis avida,	*The nature of men is desirous of novelty.*

Adjectives signifying necessary, agreeable, fitting, friendly, easy, near, like, and their opposites, in most cases govern the dative; such are—

Æqualis, *equal.*	Finitimus, *neighbouring.*	Propinquus, *near.*
Æquus, *just, fair.*		Propitius, *favourable to.*
Affinis, *kindred.*	Idoneus, *suitable.*	
Amicus, *friendly.*	Infensus, *unfriendly.*	Similis, *like (outwardly).*
Aptus, *fitted for.*	Infestus, *hostile.*	
Cognatus, *related.*	Necessarius, *requisite.*	Utilis, *useful.*
Consentaneus, *suitable.*	Obnoxius, *exposed to.*	Vicinus, *neighbouring.*
Contrarius, *contrary.*	Par, *equal.*	

These examples will be found illustrative—

Patri similis,	*Like his father.*
Omnibus supplex,	*Submissive to all.*
Jucundus amicis,	*Agreeable with his friends.*
Est finitimus oratori poëta.	*A poet is nearly related to an orator.*
Os humerosque deo similis,	*Like a god in features and limbs.*
Ædificia fere Gallicis consimilia.	*Nearly resembling the buildings of the Gauls.*
Eorum supplicia gratiora diis immortalibus esse arbitrantur,	*They believed that their punishment would be very agreeable to the immortal gods.*

PHYSIOLOGY—CHAPTER II.

THE SKIN—PERSPIRATION—CLEANLINESS.

THE skin is the elastic and distensible outer covering of the body. It serves a variety of important ends. Considered merely as that soft, supple, pliable web which forms the outward vestment of the human frame, the skin is distinguished by the possession of the following important qualities—it is tough, flexible, elastic, porous, and resistent. It is a strong, intricately organized, exceedingly vascular, and highly sensitive membrane. This dense, firm tissue of nerves and blood-vessels, which you cannot puncture anywhere, even with the finest needle or the minutest thorn, without causing pain and drawing blood, is sheathed in a delicately wrought overcoat of tissue, consisting of myriads of minute, thin, transparent scales which, though insensible themselves, permit all sensory impressions to pass through them unhindered. Simple and uniform as it seems to be, it is really a compound of many elements and parts, and the seat of a great many different functions. It is (1) a protecting envelope for all the delicate parts of the animal frame. It thus enables the various parts of the body to come into contact with external objects without experiencing that pain which, as we all know, is felt when any foreign substance touches a part of the surface denuded of skin. It is (2) the seat of the sensation of touch. It gives us important information about the external world, and corrects for us many of the fallacies to which some of the other organs of sense are liable. It is (3) one of the purifying organs. By the perspiration which flows through it the blood is freed from much of the worn-out and refuse matter which it accumulates while passing through the body. It is (4) a preservative of the temperature of the body at the proper degree, by the evaporation of the sweat which is poured out on its surface. For these various uses the skin has a complicated structure, but in every part of the body its texture is similar, though somewhat modified to suit particular situations. It is principally as the organ of perspiration that we shall refer to it here; on another occasion we shall consider its use as an organ of sensation.

The skin or common integumentary structure consists essentially of two distinct layers—the true skin and the scarf skin, or the *cutis* and the *cuticle*. The former is that which rests on the deeper tissues of the body, usually on a layer of fat; the latter is the protecting sheath of the exposed sensitive surface of the body. The true skin is part of the living organism, and is provided with vessels and nerves, is vascular and sensitive, and is influenced by all the variations of the circulation. The scarf skin is a production of the true skin, and is formed by it. As it is continually being worn away on the surface, the growth from below takes the place of that removed, by this wear, from the top.

The cutis or true skin is tough, vascular, and sensitive. It has two surfaces, (1) that which rests on the deeper structures, and (2) that which comes in contact with the cuticle. This we know from our experience in the case of a blister arising from a burn or produced by irritants. The serous fluid separates the scarf skin from the true, and raises it so that it may be plainly seen. If this upper netting be removed, the true skin is exposed and pain is felt. The deep part, called the *corium* or *derm*, consists of waving fibres, sometimes containing contractile threads among them. These waving fibres are arranged so as to be disposed circularly round the hairs, and when the surface of the body is exposed to cold the contractile fibres collect in small circles round the hair, elevate the surface at this point, and so produce a little cone, causing that curious appearance called "goose skin," with which we are all familiar when we are cold. At certain parts, as in the eyelids, the dermal structure is very thin and loose, and is easily swollen with blood or fluid. Hence the great swelling caused by a blow on the eye. At most other parts the corium is tough and thick. It is especially so over parts exposed to much pressure, as the hips and soles of the feet. Small foreign particles are sometimes retained in the cutis for a lifetime. The process of tattooing consists in making punctures into the true skin and thus introducing coloured material, which remains permanently visible.

The upper papillary surface of the cutis, that part which comes in contact with the scarf-skin, has a very remarkable arrangement. It is more vascular than the reticulated layer just described. The vessels which pass from below through the corium become more branching and tufted, and arrange themselves into semi-transparent, flexible little cones, the nerve-filaments of which—most probably looped—project up from the surface towards the scarf skin. These are called the tactile papillæ or touch-points, and the surface presenting this appearance is sometimes called the papillary layer. Each papilla has a nerve sent to it, and the sensibility of the skin depends on the number of papillæ in a given portion of surface. In certain regions they are closely set in double rows, so as to pack a larger number in a small space, and on the points of the fingers these rows are arranged in beautiful waving lines, so as to allow of the papillæ being set as thickly as possible on these sensitive parts.

The epidermis, or scarf skin, varies in thickness in different regions, and is very dense in all parts exposed to friction and pressure, especially on the soles of the feet, and is sometimes so thickened over the joints of the toes as to form corns. It is changed in character in certain regions, to form nails and hair, and in the lower animals is further modified into the various kinds of scales, claws, fur, feathers, and horns; for, strange as it may appear, all these are but appendages of the skin, as will afterwards be shown.

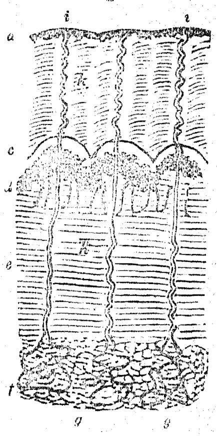
Fig. 1.

Skin of Negro.
a, The cutis, dermis, or true skin; *b'*, the pigmentum, or colouring matter of the lymphatic network; *b*, the epidermis or cuticle.

This layer of the skin used formerly to be described as consisting of two layers, the *rete mucosum* or mucous layer, and the cuticle or scarf skin; but this arose from an accidental mode of preparation, and was also founded on the fact that the portion of the cuticle next the true skin is always moist, while the external surface of it is usually dried by exposure to the air. The two parts are essentially the same in structure, and only modified by the circumstance mentioned. The tinged portions of the skin in *white* races depends on the deposit of pigment in the deeper parts of the cuticle. In the negro the deeper layer of the cuticle is found to contain a larger quantity of black pigment, while the surface of the skin is usually as transparent as in the white man (fig. 1). It is also found that the boundary line between the two layers is not abrupt, but that the coloured part shades into the colourless.

The cuticle is extra-vascular, that is, it is not supplied with bloodvessels nor does it contain nerves; hence we can cut a certain thickness of skin from the surface without either feeling pain or drawing blood, but if we pass the knife too deep—that is, through the cuticle and touch the cutis—we have reached the "quick," and we cause blood to flow. The cuticle is constantly growing from the surface of the cutis; small particles are formed on the external surface of the papillary layer, which imbibe nourishment from the vessels of the cutis and acquire the form and shape of small round cells. No sooner are these formed than a fresh layer of particles grows from the cutis, pushes up that just perfected, and is in turn replaced by another growth. As the former layer is pushed out it is removed from the neighbourhood of the vessels of the cutis, ceases to receive nourishment, becomes exposed to external agencies, as the air and pressure from the surface, and so is changed in character; the round cells of which it is formed become flattened, lose some of their fluid contents, and soon become altogether dried, so that they are changed from moist globular bodies to flattened scales, which on reaching the surface are in turn rubbed off and replaced by others from below. In certain regions, as the scalp, these are readily observed as "the scurf," and in other situations, as on the palms and soles of the feet, they can be peeled off in considerable sheets, especially after the surface has been irritated by any unusual friction. The whole thickness of the cuticle is sometimes separated from the true skin during life by the pouring out of fluid from the vessels of the cutis. When the skin is submitted to very gradual pressure or friction, the vessels of the cutis are stimulated, and a rapid growth of cuticle takes place, so that the skin becomes hardened and suited for the friction; but if the friction is too long-continued at a time, or too forcibly applied all at once, the vessels are over-stimulated, the cutis becomes engorged, it pours out the fluid of the blood on its surface, and so raises the cuticle as to form a blister. The parts soon regain their natural condition, and become habituated to the friction, so that it is borne with impunity. Thus parts of the skin, however delicate, adapt themselves to modified circumstances. In the case of those who have undergone amputation of the leg and walk with the knee on a peg, the skin on the knee becomes as thick as that on the sole of the foot. For the purpose of illustrating plainly the structure of the skin we present (fig. 2) a magnified section of the skin of the finger.

Fig. 2.



Section of Skin of Finger, magnified 14 times.
a b is the epidermis; *c* the colouring matter; *d* the *rete mucosum*; *e* the derm or true skin; *f* the fatty tissue under the skin; *g g* the sweat glands; *h h* the spiral canals which carry the perspiration to the surface *i i*.

Corns and *warts* consist of elevated and hardened portions of cuticle. In the case of corns, the pressure of a tight boot or the friction of a too large one—for corns may be produced by loose as well as tight boots—excites the skin to form a fresh layer of cuticle, and this, being unable to rise in consequence of the pressure or rubbing of the leather, is matted down on the sensitive papillæ; and so we can readily understand how very painful it is to have a corn pressed on. The continued presence of a corn in turn excites the true skin, which becomes more sensitive than is natural. Thus the pain of a corn is not produced by the pressure of a hard knot of skin on the ordinary true skin, but on a highly sensitive surface, which becomes more so the longer the corn exists.

Warts are small button-like collections of over-elongated papillæ, adhering closely and incased in thick hard dry cuticle. By exposure to the air and friction they get a sort of horny texture and consistency. They are generally due to some local irritation, and most commonly make their appearance on the hands and fingers. Some are more fleshy and vascular than others, and are consequently more troublesome; some are due—like that to which chimney-sweepers are exposed—to the result of special irritants. Warts generally shrivel up spontaneously and disappear in a capricious way, but if

obstinate and painful they should be dealt with by the surgeon.

If the external surface of the skin be carefully examined with a common lens a vast number of small pits will be discovered, studded all over it. In the fingers they are seen on the summit of the ridges as produced by the arrangement of the papillæ in lines. These little pits may be called the pores of the skin, although they are not true holes, but only the funnel-shaped orifices of little tubes, which, passing through the skin, open on its surface. They are the openings of the sweat glands, and are of vast importance in the animal economy. If we could pull out a sweat gland by its little tube, it would look like a spiral thread with a twisted knot at the end. A sweat gland consists of a little tube curiously coiled up into a ball. A spiral part of the tube, which leads from this little ball—which is situated in a small hollow in the deep part of the cutis—through the cuticle to the surface, is called its duct. On certain parts of the body, as the armpits, the sweat glands are quite large enough to be seen by the naked eye when the skin is turned down. They are the size of a small pin's head. The number of pores, and consequently of perspiratory glands, differs in different parts of the body, but the number of them points to the great importance of their function. It has been calculated that there are 17,000,000 pores on the surface of the body, so that if all the little tubes with which these are connected were drawn out, unravelled, and joined end to end, they would reach the extraordinary distance of 28 miles. Such an apparatus of tubing must evidently serve some very important ends. The ends are mainly twofold—(1) *Excretory*. This has been proved by the facts (*a*) that animals prevented from perspiring die as certainly, though not so rapidly, as those which are prevented from respiring; (*b*) that diseases of the heart, lungs, liver, kidneys, &c., are encouraged and increased by neglect or suppression of perspiration; and (*c*) that free perspiration relieves and modifies inner congestions. (2) *Absorptive*. Towards the proving of this the following facts tend:—(*a*) A person immersed in a bath, especially after long fasting, gains a perceptible increase in weight; (*b*) sailors who cannot get fresh water to drink find their thirst allayed by having their clothes soaked in salt water; (*c*) in severe cases of dysphagia—difficulty in swallowing—immersion in a bath of milk and water not only moderates thirst, but nourishes the body; (*d*) the insensible perspiration, if it gets fixed and concentrated on the skin, acts as an energetic poison, because taken back again into the system; (*e*) mercurial preparations, when rubbed into the skin, induces similar effects as if taken internally; and (*f*) ointment of antimony, when similarly rubbed into the skin, often excites vomiting.

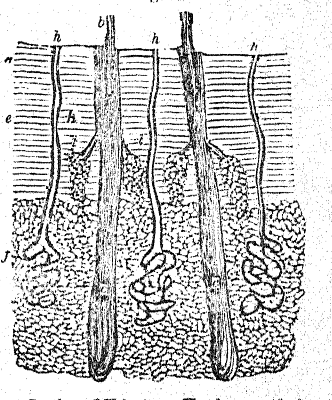
Perspiration (or *sweat*) is a vapour which passes off through the pores of the skin from all parts of the body. It generally evaporates freely and gently in the form of an imperceptible exhalation, and is then neither visible nor tangible. But when the evacuation is prevented by clothing which will not allow it a passage, or is greatly increased in amount by the action of external heat, by violent exercise, or by both combined, it collects and transudes in a liquid state in the form of small drops of moisture. These drops have a saltish taste, contain some chloride of sodium and ammonium, phosphate of lime, as well as some other salts and organic matters of a morbid and insanitary sort. It is therefore an exudation that requires to be constantly exhaled from the body to free the blood from impurity, and to preserve us from disease and premature death.

A large quantity of old, used, altered, and waste particles of matter require to be removed by various means and operations from the living body; and such portions of our food as are found to be innutritious have also to be dismissed. The skin is charged with the responsibility of throwing off a large amount of this unwholesome stuff in a way peculiar to its own extensive, ever-active, and exceedingly porous structure. About 2 or 3 lbs. avoirdupois of perspired matter pass through the skin of a full-grown person every twenty-four hours. We can easily understand, therefore, how important it must be to have this evacuatory organ always in efficient action. Because every hour that this effete injurious matter remains or is allowed to accumulate in the body we must have this unnecessary burden weighing on the organs and impeding their action, or grievously overtask some other organ to overtake the work of its expulsion, in addition to performing its own proper amount of work. We all know from experience, and are almost always surprised at the fact, that unusual or extreme cold applied suddenly to the skin, or continued exposure to the air of a cold day, in the case of those who are unaccustomed to such influences, will produce a severe oppression in the chest or head, a bowel complaint, or an inflammatory attack on some internal organ. This shows us how suppressed perspiration induces disease, and it would be well for us if we could (or rather would) remember that there is an extreme sympathy of action and condition between the lungs, the liver, the bowels, the kidneys, and the skin, because they have all, in point of fact, a similar office to perform—the sanitary cleansing of the waste and unwholesome matter from the system. While the morbid obstruction of perspiration often results in serious internal functional derangement, and ought therefore to be carefully guarded against, it is a beneficial thing to know that the promotion of a free flow of perspiration, or the removal of any obstructive interference with its proper and legitimate operations, has a pre-eminently sanitary effect. Hence the efficacy of well-regulated bathing and the advantageousness, among other things, of careful and suitably arranged athletic exercise.

There are two kinds of perspiration, sensible and insensible. The *sensible* can always be felt and perceived, for it constitutes visible sweat; the *insensible* passes off in the form of an airy vapour, and we are not so conscious of its constant evaporation. Sweat is a secretion of the internal tissues of the skin. Its exhalations pass through the external *cuticle* by innumerable minute pores, imperceptible to the human eye, except by the help of a large microscope. When we see a person covered, as we say, with "large drops of sweat," we may be sure that they have all passed through these minute pores; only that having been perspired more quickly than exhaled, they have gathered on the surface, and glisten on it "like blobs of dew." Persons in this condition should neither expose their bodies suddenly to a cold damp atmosphere nor take any copious draught of cold water, for outward cold causes the large drops to coagulate, closes the pores of the cuticle, and obstructs perspiration; and inward chill interferes with the healthy action of the important organs of the interior.

If we live in a cold atmosphere in which our perspiration is checked, our vital heat is retained; if in a warm atmosphere where perspiration is profuse, the heat of the body is discharged; hence the varied quantities of perspiration exhaled in warm and cold atmospheres help to equalize our animal heat, and make it suitable to the exigencies of the different climates to which we are exposed. Thus, the human body is able to support the heat of a warm sunny day in the summer, and endure the winter's cold, when "icicles hang by the wall." It is this adaptative power which enables a Livingstone to accommodate himself to the intense heats of equatorial Africa, and a Parry to venture over the northern icefields to within 8 degrees of the pole.

Fig. 3.



Section of Skin from Head, magnified 14 times.

i, *i* represents the sebaceous follicles; *c* the hair follicles; *h* the sweat glands; *f* the fatty tissue; *e* the derm; *a* the epidermis; *b* the projecting hair.

Besides perspiration, there is an oily exudation which proceeds from the sebaceous glands of the skin (fig. 3). It appears to be useful in giving pliancy and softness to the scales of the cuticle, the crackling and breaking of which it prevents. This peculiar fatty matter readily concretes and becomes

visible as dust or scales in the skin, and as roughness or scurf on the hairs of the body. The use of this exudation is to keep the skin from being penetrated and relaxed in its fibre by water. It is necessary, however, that it should be removed as soon as it has done its duty as ointment to the hair and lubricant to the skin, and it ought not to be allowed to accumulate on the skin or the clothing. The sebaceous glands are also the seat of the hair-follicles or sacs. Each hair is included at its lower part in an extremely delicate sheath, which passes slantingly through the skin in or beneath which it is situated, and there terminates, at a greater or less depth, in a bulbous pouch or follicle, called the hair-bulb, which contains the root of the hair. These hairs form an aid to the flow of the perspiration, afford a protection from undue exposure to the parts so clothed, and impart an additional ornament to the human body. The manner in which the skin contracts in cold or under the influence of sudden fear—technically called horripilation, and ordinarily known as goose-skin—shows that they, too, have an important office in the animal economy.

As the skin, when its functions are all healthily performed, exercises such an important influence on the physical condition of the individual, it is very necessary to preserve it from external injury, and keep it in a sound state, for the preservation of health and the prevention of disease. In our own chilly, damp, and changeable climate we ought always to wear clean, dry, soft flannel or fine pliant and elastic silk next our bodies. The upper part of our dress may be changed and agreeably suited to the season; but our flannels ought never to be removed, except when we resupply ourselves—which should be frequently—with a clean set.

The skin should be kept perfectly clean, by frequent washing and rubbing, to remove all external obstructions to perspiration, and keep the pores open for its free egress. Children should be wholly washed every day, and adults quite as often, if possible. Cold sea-bathing in summer, and a hot sea-water bath in winter, are excellent agencies for the preservation of a healthy skin. If any internal organ be diseased, the cold bath is improper. In such a case the hot bath relieves internal congestion, by expanding the cutaneous vessels for the reception of a proper quantity of circulating blood. The cold bath, on the contrary, suddenly forces the blood away from the surface of the body, and by causing it to rush into the overloaded internal vessels, injures them if diseased, and sometimes induces immediate death. Fresh water may be employed for bathing when sea-water cannot be conveniently procured.

Sudden exposure to the cold, damp night-air, especially on leaving a heated room, a crowded assembly, or any place where the temperature has been high or one may have been sweating profusely, checks perspiration, and induces catarrh. The throat, the lungs, the bowels, the liver, or the brain may thus become inflamed, according to the temperament of the patient, and serious illness may readily supervene. To live long and enjoy health we should sedulously avoid exposure to sudden cold.

Every one who would wisely arrange the plans of his life in such a way as to secure to himself the greatest of all its blessings, health—the power of being and doing well—on seeing how much of human comfort depends on the preservation of the skin in a natural and sanitary state, will not fail to provide for the thorough cleansing of the skin. He will attend to home ventilation, that the exhalations may not be retained near the person in a sluggish and stagnant atmosphere; that the clothes he wears shall be such as permits the ready passage of the matters exhaled and exuded from the skin; that they be such as shall by gentle friction prevent the unpleasant accumulation of waste matter, and shall agreeably stimulate and encourage the normal action of the perspiratory glands; and that by regular, judicious, and oft-repeated ablutions and rubbings, the whole excretory and secretory functions of the skin be performed faithfully by structures whose health has been sedulously cared for.

It may be advantageous to put now into a condensed tabular form the main gist of what has been stated in the foregoing paragraphs.

Definition of Skin.—The outer elastic, flexible, tough, protecting tissue which covers the entire body.

I. Structure.

It consists of two distinct layers.

(1) The *epidermis*, cuticle, or scarf-skin — the outside layer. It is firm, insensible, destitute of nerves and bloodvessels, and consists of thin, transparent, minute scales.

(2) The *derm*, *vera cutis*, or true skin—the inner layer or corium, sensitive, vascular, organized, abundantly supplied with nerves and bloodvessels, and readily susceptible of injury.

(3) The *rete mucosum*, mucous coat, or pigment texture—lying between 1 and 2, soft, mucilaginous, intricately ramified with nerves and bloodvessels, and containing colouring matter.

(4) *Pores*. — The extremities of small twisted tubes, of great minuteness, embedded in the dermis.

(5) *Sweat Glands*. — Tubes with spirally twisted ends, in which perspiration is secreted, and by which it is excreted.

(6) *Sebaceous Glands*. — Small, whitish sacs of fatty matter, with a sort of pear-shaped terminal dilation.

(7) *Papillæ*.—Small, thickly set, conical, nervile projections, on the surface of the true skin, and under the cuticle.

II. Uses.

1. It defines, by inclosing it, the form of the body.
2. It protects the underlying parts from injury and pain.
3. It modifies the action of the surrounding elements on the body (1) sensibly, and (2) insensibly.
4. It is one of the main outlets, by perspiration, of waste matter.
5. It aids greatly in the regulation of the temperature of the body.
6. It is the organ of feeling or touch.
7. It absorbs matter from without.

III. Practical Lessons.

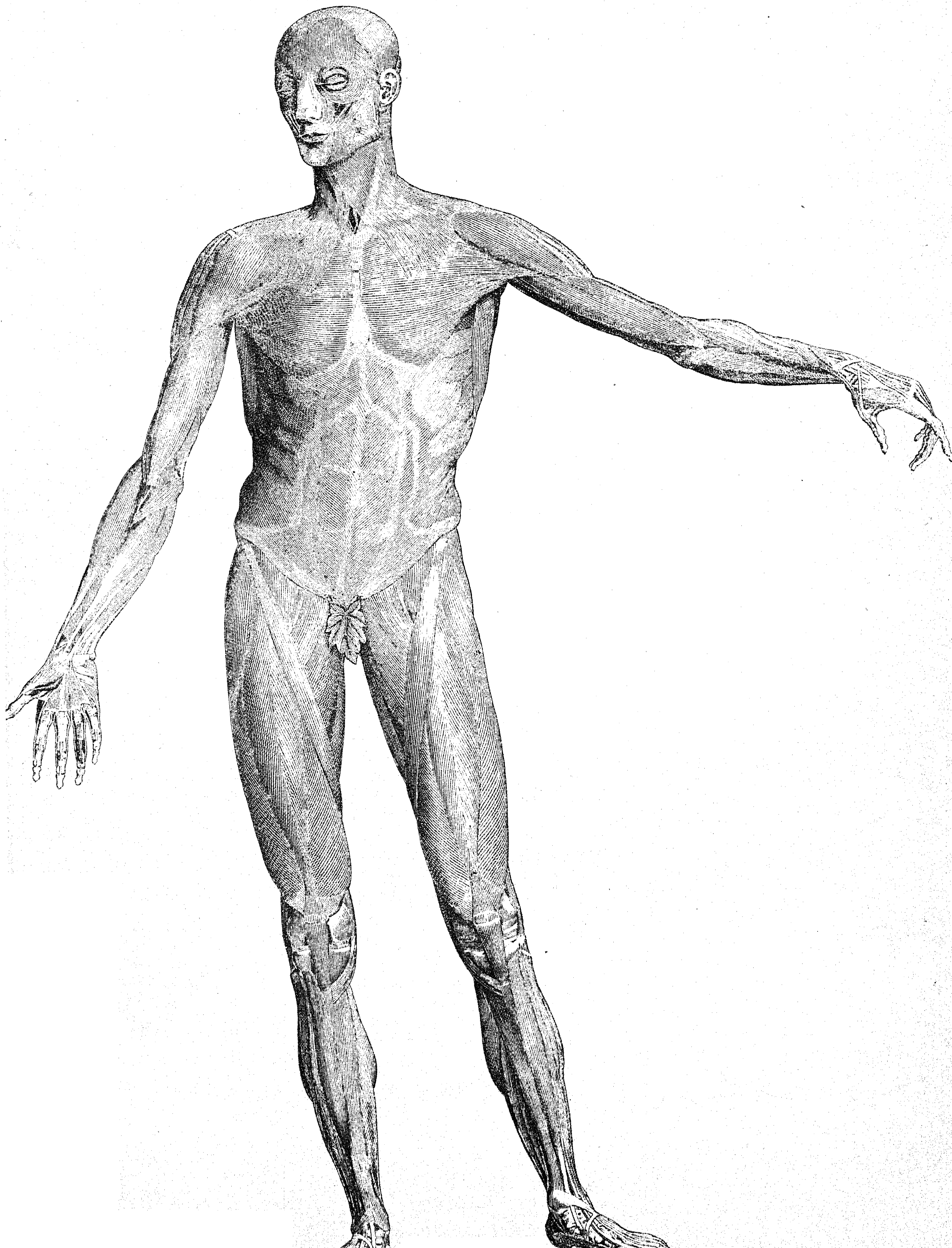
1. The necessity and importance of cleanliness.
2. The propriety of avoiding draughts and chills.
3. The benefits of bathing, friction, and exercise.
4. The need of a frequent change of raiment—especially underclothing.

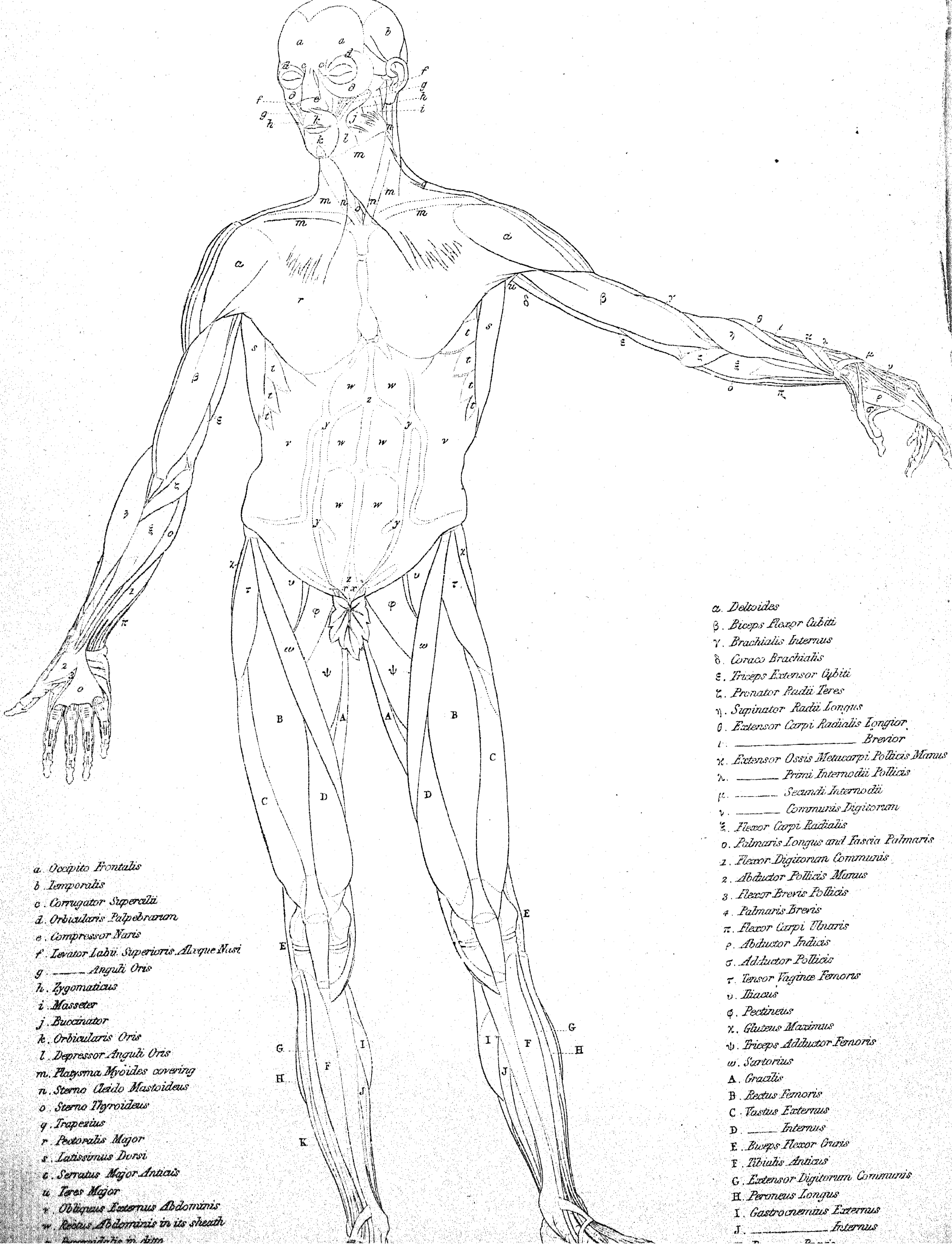
CHAPTER III.

THE MUSCLES AND MUSCULAR ACTION.

Every motion of the body is performed through the agency of its muscles; they move us from one place to another, and without them we could not enjoy the pleasures of locomotion.

The human skeleton—the framework of the locomotive machinery of the body—has been already described. The osseous structure is, however, draped in flesh, which is the common name given to muscular tissue. The man who has never examined and studied the mechanism and functions of the *muscles* is apt to conclude that the flesh is a solid mass, without any other use than to cover the bones, and constitute by its bulk the external portion of the body. But when he minutely examines it, he perceives that it is mechanically constructed; separated into long, broad, thin layers, lying side by side, and above each other; that each muscle is composed of long slender fibres, each inclosed in its own sheath; and that, individually and combined, they perform every motion of the animal machine. Those organized masses of reddish fibres form a soft cushion, inclosing and protecting the vital organs stored up within the walls of the body, and impart symmetry to the figure. We know that if we take a piece of fleshy meat and tease it a little, so as to deprive it of its connective binding material, it will divide into slips or fibre, and appear as thread-like, extremely fine, stringy filaments. These filaments are arranged in bundles or packets (technically named *fasciculi*) encased in sheaths of areolar tissue, which at once connect them into a bundle and disconnect them from the other bundles which lie alongside of them. These sheaths receive the name of sarcolemma or flesh-holder, or myolemma, muscle-case. Each *fasciculus* which is so invested, when microscopically examined, is found to consist of a number of cylindrical *fibrillæ* laid longitudinally parallel to one another, and carefully enwrapped into singleness though lying exceedingly close to the other fasciculi, which together form a muscle. These fibrillæ, the ultimate elements of flesh, consist of syntonine (Gr. συντείνω, I draw tight), a coherent, elastic, coagulable form of matter which constitutes the essential base of every contractile tissue, and is closely analogous to the coagulable fibrine of the blood. The fibrillæ may be defined as a series of elongated fibre-cells, and reversing the





a. Occipito Frontalis
b. Temporalis
c. Corrugator Supercilii
d. Orbicularis Palpebrarum
e. Compressor Naris
f. Levator Labii Superioris Alæque Nasi
g. ——— Anguli Oris
h. Zygomaticus
i. Masseter
j. Buccinator
k. Orbicularis Oris
l. Depressor Anguli Oris
m. Platysma Myoides covering
n. Sterno Cleido Mastoideus
o. Sterno Thyroideus
q. Trapezius
r. Pectoralis Major
s. Latissimus Dorsi
t. Serratus Major Anticus
u. Teres Major
v. Obliquus Externus Abdominis
w. Rectus Abdominis in its sheath
y. Pyramidalis in ditto

α. Deltoides
β. Biceps Flexor Cubiti
γ. Brachialis Internus
δ. Coraco Brachialis
ε. Triceps Extensor Cubiti
ζ. Pronator Radii Teres
η. Supinator Radii Longus
θ. Extensor Carpi Radialis Longior
ι. ——————— Brevior
κ. Extensor Ossis Metacarpi Pollicis Manus
λ. ——— Primi Internodii Pollicis
μ. ——— Secundi Internodii
ν. ——— Communis Digitorum
ξ. Flexor Carpi Radialis
ο. Palmaris Longus and Fascia Palmaris
1. Flexor Digitorum Communis
2. Abductor Pollicis Manus
3. Flexor Brevis Pollicis
4. Palmaris Brevis
π. Flexor Carpi Ulnaris
ρ. Abductor Indicis
σ. Adductor Pollicis
τ. Tensor Vaginæ Femoris
υ. Iliacus
φ. Pectineus
χ. Gluteus Maximus
ψ. Triceps Adductor Femoris
ω. Sartorius
A. Gracilis
B. Rectus Femoris
C. Vastus Externus
D. ——— Internus
E. Biceps Flexor Cruris
F. Tibialis Anticus
G. Extensor Digitorum Communis
H. Peroneus Longus
I. Gastrocnemius Externus
J. ——————— Internus

French emphasizing of a fact in the epigram "the blood is liquid flesh," we may define flesh as "solidified blood," the sarcous textural elements of which are muscles.

A muscle is composed of long, slender, contractile fibres, which are everywhere enveloped in common cellular membranes. These fibres become fewer and ultimately terminate as they approach the extremity of the muscle. Their enveloping cellular substance being thus freed from the muscular fibres comes more closely together, and forms itself into a white, round, stringy, or flattened tendon. When the muscular fibres contract, their power, united on the tendon, draws it up and makes it perform the action of a pulley. Tendons are composed, not of muscular fibres, but of the fibrous substance with which they are enveloped. Every muscle is supplied with arteries, veins, lymphatics, and nerves; for without these they could neither grow, renew, nor contract. Their vital power is derived from their nerves. The active parts of the system are, then, the muscles and nerves—the muscles, to move the body; and the nerves, to move the muscles to action.

When the fibres of which muscular tissue is composed are examined under the higher magnifying powers of the microscope, they are seen to be different from one another in being *striated* (striped) or unstriated (uncrossed by transverse bars or stripes). All the involuntary muscles—with one singular exception, the heart—are unstriated. All the voluntary muscles, those, that is, which can be controlled to a greater or less extent by the will—as well as the heart, which is beyond the government of the will—are striated. The free muscles of the head, neck, trunk, and limbs, the tongue, the heart, and the diaphragm, consist of striped fibres, and are distinguished by their fleshy-redness. These fibres for the most part run close to each other without any mutual connection; the unstriped fibres mostly surround and inclose tubes, such as the alimentary canal, the gall and urinary bladders, and the excretory ducts of glands. These two kinds of muscles are distinguished not only by their form, but by the mode in which they contract. Motor-nerves are interlaced with the substance of the striated muscles, and act upon them to produce contraction, but the unstriped muscular fibres seem to have an independent power of contraction. Muscles grow by the increase of bulk, not of the number, of their fibres; and the number is probably the same through man's whole life. Their substance is remarkably elastic, and it is this extreme tough resiliency which makes them so variously useful in their interaction.

Muscles are of two kinds, simple and compound. The simple are called *ventriform* when their bulge is large, but diminishes in size as they approach their tendons (fig. 4); *parallel* when they terminate in a broad fibrous web, without tendons (fig. 5); *penniform* when their fibres run parallel, but obliquely, to their tendons, like feathers on one side of a quill (fig. 6); *double-penniform* when two ranges of parallel fibres pass obliquely into a tendon running along their centre (fig. 7); *double-bellied* when they have two bulges meeting, and inserted into one tendon (fig. 8); and *fan-shaped* when they are broad and thin at the origin, and thick at their insertion into the tendon (fig. 9).

Different muscles accomplish very different purposes:—(1) They envelop, compress, and sustain the viscera or internal organs of the abdomen or belly. (2) They lengthen, shorten, or compress some organ or organs, such as the tongue, &c. (3) They widen or contract some opening, as the sphincter muscles do, at the entrance of the natural passages of the body. (4) They roll or move the organs of the senses, such as the eye, ear, &c. (5) They relax, pull up, or make rigid, a valve, as the epiglottis; a septum, or division of parts, as the velum pendulum palati, or veil of the palate, &c. (6) When they are inserted, or attached to bones, we by their action perform locomotion, as walking, running, leaping, dancing, &c.

The muscles, especially of the extremities, are called either flexors, extensors, pronators, supinators, adductors, abductors, or rotators. The *flexors* bend or draw down the limb, or the part to which they are attached, if it has a movable joint, and are placed under that part of the body on which they act, as antagonists to the extensors. The *extensors* raise, elevate, and extend the movable parts to which they belong, and are placed on the upper surface as antagonists to the flexors. *Pronators* turn the palm of the hand downwards, *supinators* turn it upwards; *adductors* draw two parts of the body together, *abductors* draw one portion away from another, and *rotators* cause a limb to turn on its axis. In short,

Fig. 4.

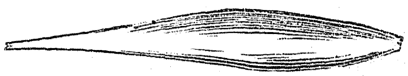


Fig. 5.

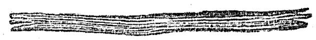


Fig. 6.

Fig. 7.

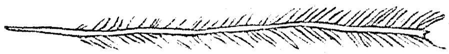


Fig. 8.

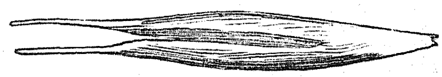
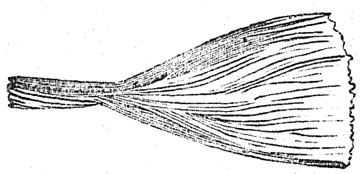


Fig. 9.



muscles are as varied in form as in action, and are each perfectly adapted to the purposes for which they are formed and designed.

Muscular tissue has the property of contracting when stimulated. In the living body the nerves have the power of exciting the muscles to contract, but muscular tissue may also be stimulated by irritation. Contractility belongs absolutely to the muscle, and exists in some cases without nervous vitality. There is, therefore, a distinction betwixt nervous sensibility and muscular irritability. Muscles are irritable and contractile by a principle inherent in their fibres, and are sensible through the vitality communicated by their nerves. Though nerves are sensible they are not contractile, and cannot perform the functions of muscle.

Muscles are of two kinds, voluntary and involuntary. Those by which we swallow food are voluntary; the muscular fibres of the stomach act involuntarily on its contents. Other muscles act—as in walking, jumping, lifting a weight, speaking, singing, or dancing—in obedience to our will. We are conscious of an effort when we call them into action, so the muscles of these parts are voluntary; but the heart moves without our will, and is therefore an involuntary muscle. The nerves convey the impressions or commands betwixt our will and our muscles. The muscles alone possess and employ contractile power. Nervous power is sometimes exhausted and apt to change. Muscular power is always perfect, and ready to act (when stimulated) in obedience to our will; but the muscles soon lose this contractile power when deprived of sensibility by the paralysis of their nerves. The involuntary muscles are mechanically stimulated without our control by what is called reflex action from some of the nerve centres; the voluntary are put into action by the impulses of the mind, and are under our arbitrary commands. The muscles of the body are double, on each side equal in number, action, and power; so that the muscles on one side balance those on the other. If on one side they are paralyzed and cannot contract, those on the other, exerting their usual strength, destroy the balance of power; in palsy of one side of the face, this fact is visibly illustrated. Sensibility de-

pends on the nerves, motion on the muscles, yet both are necessary, in the living animal, to produce locomotion.

Though some muscles—like those of the heart, the blood-vessels, the alimentary canal, the bladder, &c.—are hollow, and may be said to act within and by themselves, yet for the most part the muscles of the human body are attached to bones, which they use as levers.

A lever is a rigid bar, which may be either straight or curved, supported in some part of its length on a fulcrum, and having the weight to be moved and the power to move it at other points. In the arm, for instance, the forearm is the lever, and anything held in the hand is the weight; the elbow socket constitutes the fulcrum, and the power is the contractile force of the biceps working from the front of the humerus. The whole muscular system exhibits a most ingenious and perfect application of the laws of mechanics for the production of motion. The tendons of many muscles have their direction changed by being passed round pro-minences, over which they act, like ropes passing round a pulley, while the synovial fluid keeps the part carefully oiled to diminish friction. Where no bone seems to be suitable for such movement, a band or strap is passed over the tendon, and below and against this they can pursue their course.

The mastoid process laterally, and the occiput posteriorly, are levers for the head; the spinous processes of the vertebræ for the back; the olecranon or elbow for the arm, and the pisiform bone for the hand; the pelvis or basin, and the trochanters of the thigh bones, are levers for the thigh; the patella or knee-lid for the leg; the heel bone for the foot, and the arch of the foot for the toes. These are the principal, but not all the levers of the body.

The muscles possess their own peculiar kind of vitality independently of the nerves. A net-like, filamentous, soft, elastic tissue not only binds and separates the muscular fibres and muscles individually and collectively, but forms coverings for the brain and nerves—sheaths for the muscles, tendons, ligaments, bursæ, and all the apparatus of the joints; and unites them into a whole by the extensions, divisions, and duplications of its own substance. Tendons, or the extre-mities of muscles—ligaments or the sinews—periosteum, or the membrane that covers the bones—and the bursæ, or the mucous bags that fill up and lubricate the cavities of joints—are all composed of this connective tissue, which not only com-bines and conjoins the parts by its elasticity, but is also a medium of communication for the rest of the system. This tissue keeps the muscles and their fibres separated at proper distances from each other, and lubricates and supports them. Its thin oily exudation (*halitus*) makes them play freely, and its fat (for this substance contains the fat of the body) not only supports them in their action, but preserves their soft-ness, and lubricates them so perfectly that deficiency is pain-ful, and its superabundance cumbersome to the individual. When muscles rub on each other, the halitus prevents friction and pain; when tendon rubs on tendon, bone on bone, or muscle on tendon, the tissue assumes another form, and its little cells running together into one large cell, with a thicker and more copious exudation or gelatinous mucus, prevent the ill effects of friction. These large cells are called *bursæ mucosæ* (mucous bags), and are placed, as circumstances re-quire them, under rubbing tendons and in large joints. To prevent friction, every muscle is inclosed in its own cellular sheath, not only to give it pliancy, strength, and form, but to preserve it in its proper position.

Tendons not only act on the bones, but give the limbs their form. Tendons are seldom required, except where muscles are inserted into bones. There is no tendon in the heart, the stomach, the bowels, the œsophagus, or the bladder; these do not require them. Their motions are wholly contractile, and they need no lever power. But where tendons pass over bones and traverse joints, their action is concentrated into narrower bounds, and their long cords being fixed to the extremities of the muscles, pull the bones and raise them in obedience to our will. Tendons have no visible nerves and have little feeling. The expansion of the palmaris, and many other tendons, may be unravelled into simple fibre-cells. The periosteum is also a condensation of connective tissue, attached in successive layers to the bones.

Tendons are implanted into the periosteum, mix with it, and become part of its substance. The tendons of muscles sometimes separate and form sheaths or rings for others. Sometimes they run in grooves formed in the bone; at other times they expand over the bones, so as to form an entire sheath for the fingers and toes; and are so firmly bound down, that they cannot start from the joints to which they are attached.

Each bone is tied to the next by its own periosteum. Betwixt the end of one bone and the beginning of the next, the periosteum is thickened into a strong hard bag, forming a capsule for the joint. The capsule contains a glairy liquor that moistens the heads of the moving bones and prevents friction. There are also strong ligaments or bands, arising from the periosteum, which surround the joints and unite them securely on every side.

There are about 450 muscles in the human subject, 225 on each side, with a small numerical difference in the male and female. In describing the muscles the anatomical name will be given not only for distinction, but for brevity's sake, for it is not possible to do justice to the subject without it. The student is recommended to peruse this entire chapter with the Plates before him. These present the human figure with the skin removed, and all the delicate elastic connective tissue which forms the padding of the frame taken away, leaving the lean fleshy fibres of the muscular system clearly in view. Plate V. supplies a front view, and a key-plate (V.A) accompanies it; so that all the separate muscles of any special importance are dis-tinctly named, and their places and relations may easily be perceived. Plate VI. presents a back view, in which, as before, the principal muscles may be traced by the help of the key-plate (VI.A). But in this the dissector's art has been exer-cised on one half of the figure to lay bare some of the more important of the inner muscles, in such a way as to show their place and the course of their action.

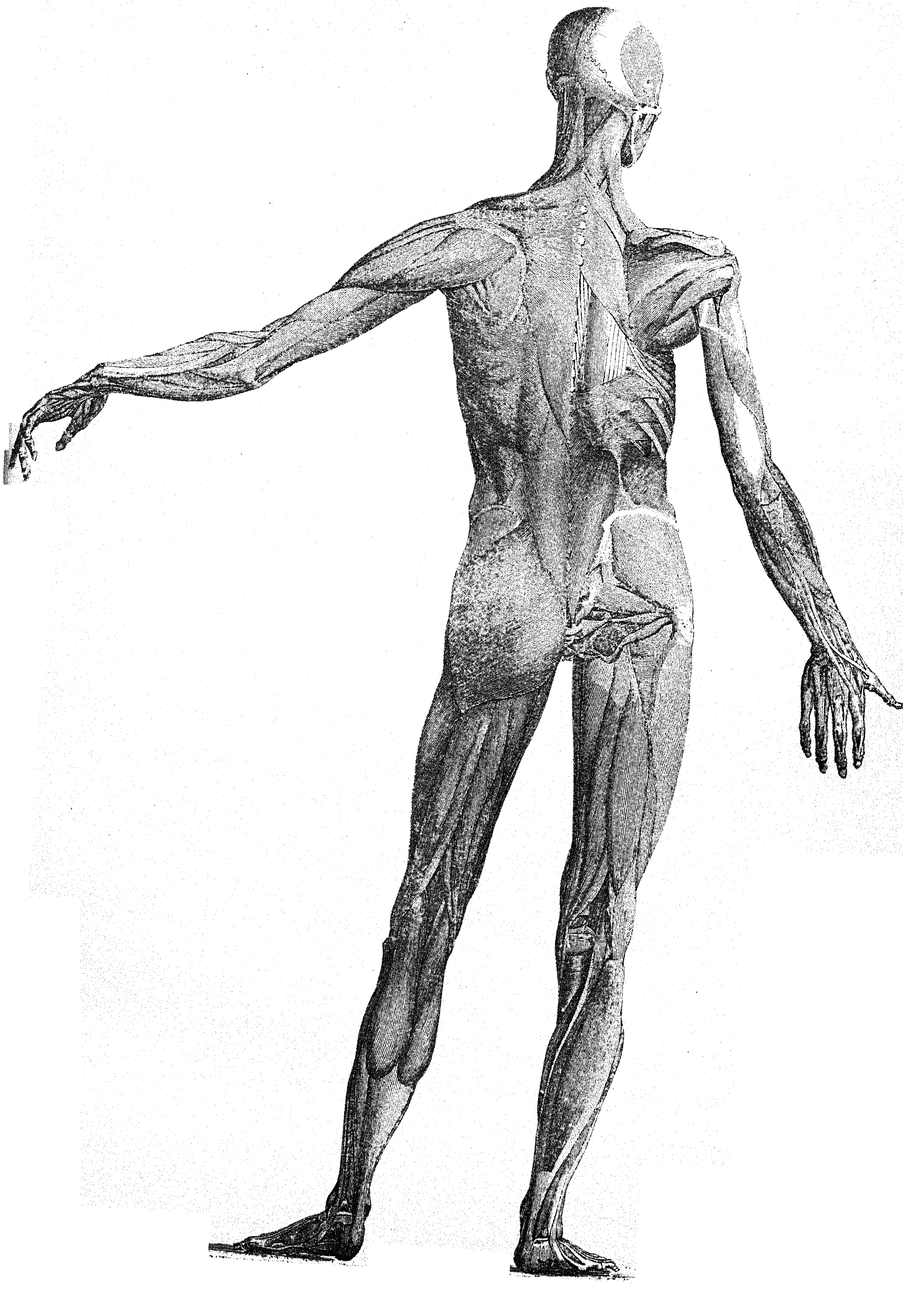
There are *four* muscles in the forehead—the *occipito fron-talis* (*k*, fig. 1, Plate VII.) covers the upper part of the cranium

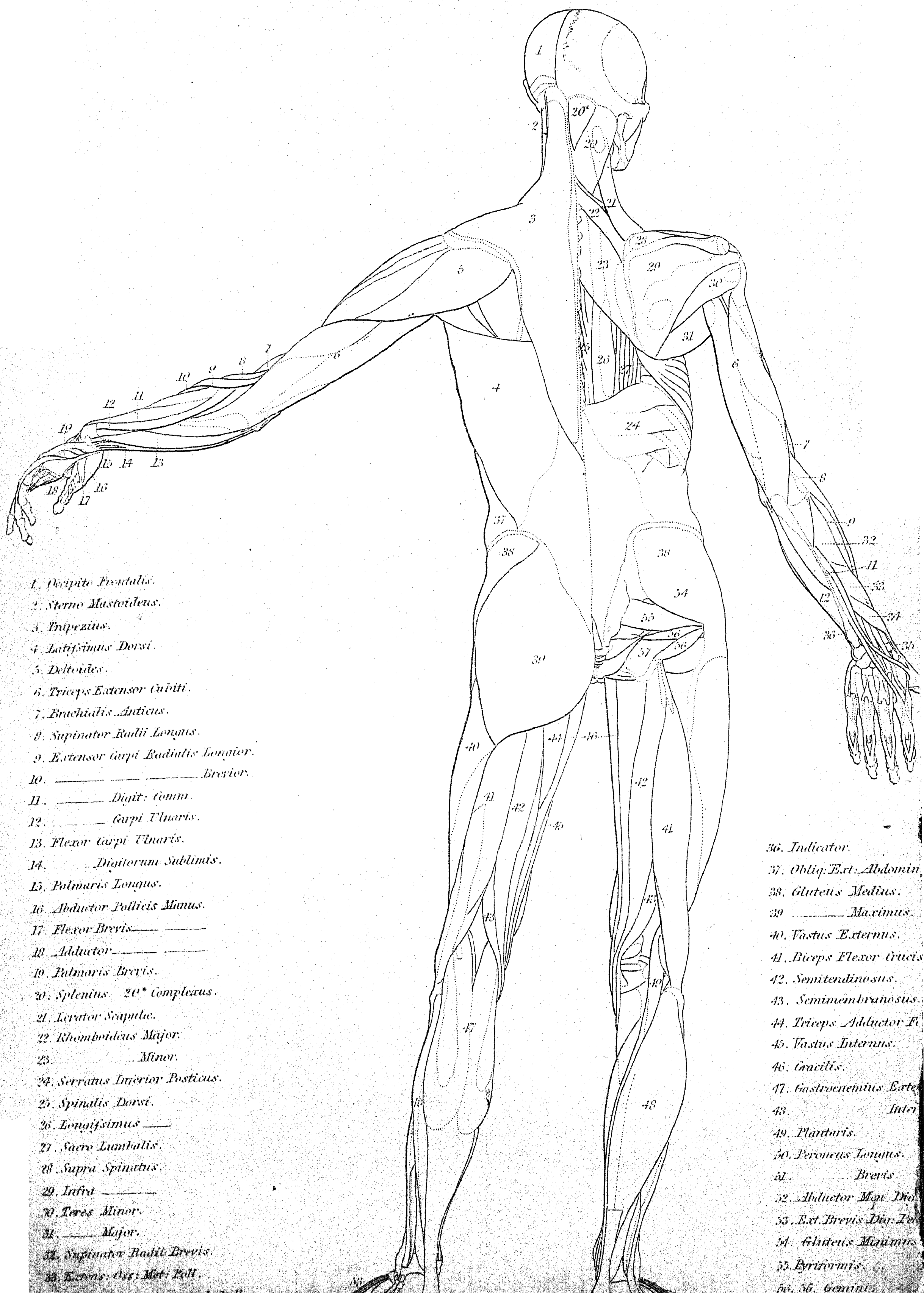
Fig. 10.

Muscles of the Face—Front View.

or skull, and wrinkles the forehead; *corrugator supercilii* (*l*) forms part of the eyebrow, and wrinkles it when we frown; *orbicularis palpebrarum* (*m*) covers and surrounds the eye-lids, presses the eyeball firmly into the socket, and squeezes the tears from the lachrymal gland; *levator palpebræ superi-oris* spreads over the upper eyelid, and forms it. When elevated the eye is open, when depressed it is shut, and when paralyzed it is also closed.

PLATE VI.





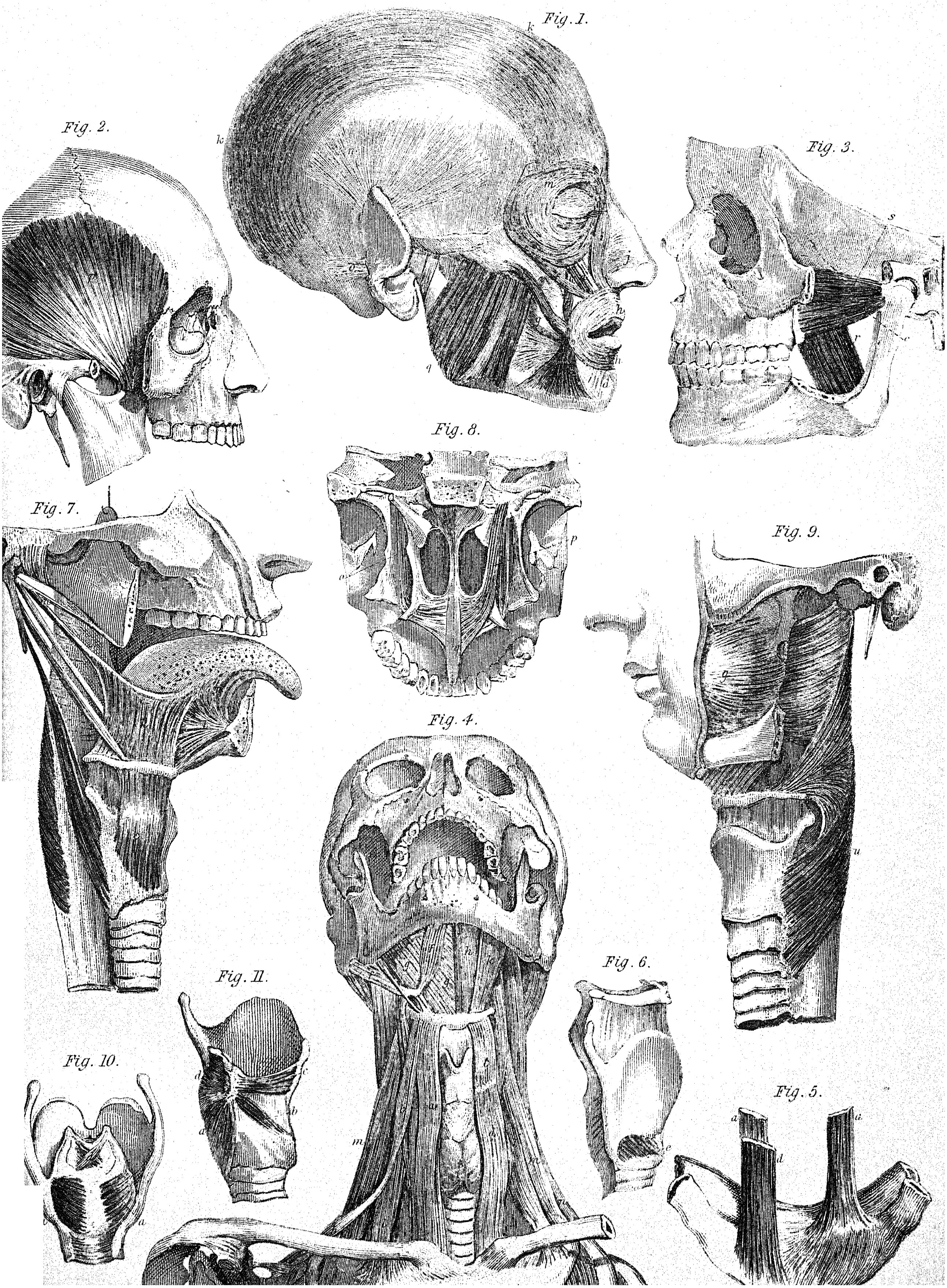
1. Occipito Frontalis.
2. Sterno Mastoideus.
3. Trapezius.
4. Latifsimus Dorsi.
5. Deltoides.
6. Triceps Extensor Cubiti.
7. Brachialis Anticus.
8. Supinator Radii Longus.
9. Extensor Carpi Radialis Longior.
10. ——— ——— ——— Brevior.
11. ——— Digit: Comm.
12. ——— Carpi Ulnaris.
13. Flexor Carpi Ulnaris.
14. ——— Digitorum Sublimis.
15. Palmaris Longus.
16. Abductor Pollicis Manus.
17. Flexor Brevis ——— ———
18. Adductor ——— ———
19. Palmaris Brevis.
20. Splenius. 20* Complexus.
21. Levator Scapulae.
22. Rhomboideus Major.
23. ——— Minor.
24. Serratus Inferior Posticus.
25. Spinalis Dorsi.
26. Longifsimus ———
27. Sacro Lumbalis.
28. Supra Spinatus.
29. Infra ———
30. Teres Minor.
31. ——— Major.
32. Supinator Radii Brevis.
33. Extens: Oss: Met: Poll.

36. Indicator.
37. Obliq: Ext: Abdomin
38. Gluteus Medius.
39. ——— Maximus.
40. Vastus Externus.
41. Biceps Flexor Crucis
42. Semitendinosus.
43. Semimembranosus.
44. Triceps Adductor F
45. Vastus Internus.
46. Gracilis.
47. Gastrocnemius Exte
48. ——— Inte
49. Plantaris.
50. Peroneus Longus.
51. ——— Brevis.
52. Abductor Min: Dig
53. Ext. Brevis Dig: Pe
54. Gluteus Minimus.
55. Pyriformis.
56. 56. Gemini.

PHYSIOLOGY.

MUSCLES OF THE HEAD & NECK.

PLATE VII.



REFERENCE TO PLATE VII.

Fig. 1. (*a*) *Levator labii superioris*
" (*b*) *Levator anguli oris*
" (*c*) *Depressor anguli oris*
" (*d*) *Depressor labii inferioris*
" (*e*) *Zygomaticus major*
" (*f*) *Zygomaticus minor*
" (*g*) *Buccinator; also fig. 9*
" (*h*) *Orbicularis oris*
" (*i*) *Levator alæ nasi*
" (*j*) *Compressor nasi*
" (*k*) *Occipito-frontalis*
" (*l*) *Corrugator supercilii*
" (*m*) *Orbicularis Palpebrarum*
" (*n*) *Attollens auriculæ*
" (*o*) *Retrahentes auriculæ*
" (*q*) *Masseter*

Fig. 2. (*p*) *Temporalis*

Fig. 3. (*r*) *Pterygoideus internus*
" (*s*) " *externus*

Fig. 4. (*aa*) *Sterno hyoideus; also fig. 5*
" (*b*) *Omo-hyoideus*
" (*c*) *Thyro-hyoideus*
" (*d*) *Sterno-thyroideus*
" (*ff*) *Digastricus*
" (*g*) *Mylo-hyoideus*
" (*h*) *Genio-hyoideus*
" (*l*) *Scalenus anticus*
" (*m*) " *medius*
" (*n*) " *posticus*

Fig. 5. (*aa*) *Sterno-hyoideus; also fig. 4*

Fig. 6. (*e*) *Crico-thyroideus*

Fig. 7. (*i*) *Stylo-hyoideus*
" (*k*) *Hyo-glossus*
" (*l*) *Genio-hyo-glossus*
" (*m*) *Stylo-glossus*
" (*n*) *Lingualis*
" (*r*) *Stylo-pharyngeus*

Fig. 8. (*o*) *Tensor palati*
" (*p*) *Levator palati*
" (*q*) *Azygos uvulæ*

Fig. 9. (*g*) *Buccinator; also fig. 1*
" (*s*) *Constrictor superior pharyngis*
" (*t*) " *medius* "
" (*u*) " *inferior* "

Fig. 10. (*a*) *Crico-arytænoideus posticus*
" (*d*) *Arytænoideus obliquus; also fig. 11.*

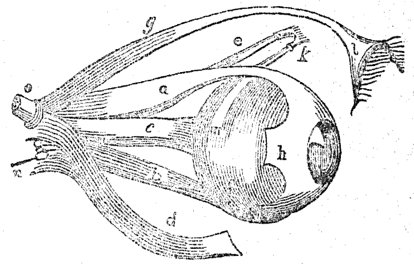
Fig. 11. (*b*) *Crico-arytænoideus lateralis*
" (*c*) *Thyro-arytænoideus*
" (*d*) *Arytænoideus obliquus; also fig. 10*

There are *twelve* muscles in the nose and mouth—(1) the *levator labii superioris & alæ nasi* (*i*) extend along the nostrils, raise the upper lip, and widen the nostrils, especially when, as in asthma, we spasmodically cough; (2) *levator labii superioris proprius* (*a*) forms part of the cheek and upper lip, and pulls the upper lip and septum of the nose directly upwards; (3) *levator anguli oris* (*b*) forms part of the corner of the mouth, and raises it upward; (4) *zigomaticus major* (*e*) forms part of the cheek, the corner and circle of the mouth, and depresses the lip; (5) *zigomaticus minor* (*f*) has its origin, insertion, and action nearly the same as the zigomaticus major. These zigomatic muscles mark the face with the line (so visible in some individuals) from the cheek-bone to the corner of the mouth, and pull the angles of the mouth upward. (6) *Buccinator* (*g*) shares in forming the walls of the cheek, flattens it, assists us in swallowing liquids, in turning the morsel we are chewing in our mouths, and likewise prevents it from getting betwixt our teeth: when we blow wind instruments these muscles dilate like a bag, then, contracting upon the wind in the mouth, expel it, and swell the notes; (7) *depressor anguli oris* (*c*) forms part of the flesh of the lower jaw and corner of the mouth, gives shape to the chin and mouth, and shows itself in laughing, smiling, and other cheerful passions: it assists in pulling the corner of the mouth downward; (8) *depressor labii inferioris* (*d*) lies on the sides of the chin, and pulls the lip downward; (9) *orbicularis oris* (*h*) lies in the red part of the lips: it surrounds the mouth, contracts and shuts it; (10) *depressor labii superioris & alæ nasi* arise from the socket of the fore teeth, go into the root of the nostril, and pull the nose and upper lip downward; (11) *compressor nasi* (*j*) lies on the side of the nose, goes to its very point, and compresses it; (12) *levator menti* arises at the root of the incisor teeth, spreads on the centre of the chin, contracts it, and forms the dimple. The muscles of the nose and mouth assist us in performing the more important functions of breathing, speaking, chewing, swallowing, &c., and opening and shutting the mouth.

On the external ear there are eight muscles—(1) *attollens auriculæ* (*n*) expands on the fascia of the temporal muscle behind the ear, terminates in the *antihelix* (or inner ring of the ear) posteriorly, and lifts the ear upward; (2) *attrahens auriculæ* arises from the zigoma (or arch of the cheek), and passes into the *helix* (or outward ring of the ear); (3) *retrahentes auriculæ* (*o*) arises from the mastoid process of the temporal bone on the side of the head, and is inserted into the back part of the *concha* (or shell) of the ear; (4) *helicis major* lies on the sharp point of the helix or outward ring of the ear, and is inserted a little above the *tragus* (the outward cartilage or gristly substance of the ear); (5) *helicis minor* lies a little lower on the ear than the helicis major; (6) *tragicus* and (7) *antitragicus* lie contiguous to each other, on the ear anteriorly, almost in juxtaposition; (8) *transversus auris* runs on the back part of the ear, from the shell to the inner ring. There are a few smaller muscles, which move and give tension to the external cartilages of the ear, and prepare it for receiving and propagating the vibrations of air along its tube. These are too minute for the general student to perceive.

The muscles of the eyeball are six in number—(*a*) *Rectus superior* (fig. 11) lifts the eye directly upward; (*b*) *rectus inferior* pulls the eye downward; (*c*) *rectus internus* carries the eye inward, towards the nose; (*d*) *rectus externus* turns the eye away; it is here represented as cut off from *h*, its insertion in the eyeball, to show the parts behind it; (*e*) *obliquus superior* (like the *recti superior* and *inferior*) arises in the bottom of the eye, above, towards the inner side, directs its long smooth tendon to the internal angle of the eye, and there passes through a cartilaginous pulley, placed above the eye, and projecting further than the most prominent part of the eyeball. The tendinous cord then returns at an acute angle, and bending its centre downward before it touches the eyeball, it turns backward in a direction opposite to the *recti* muscles, slips under the body of the *rectus superior*, and spreads under it, and upon or behind the middle of the eye, about half-way betwixt the insertion of the *rectus superior* and the entrance of the optic nerve into the eyeball. (*f*) *Obliquus inferior* is directly opposed to the obliquus superior in form, place, and office: it is a short, flat, broad muscle, arising from the orbitary process of the superior maxillary or cheekbone, near its union with the *os unguis* (or eyebone), and is inserted or expanded on the eyeball, exactly opposite the insertion of the *obliquus superior*. The *obliqui superior* and *inferior* support the eyeball for the

Fig. 11.



Lateral view of the Eyeball seen from the outer side, with its Muscles.

operation of the *recti muscles*; for when the oblique muscles act and pull the eye forward, the recti muscles resist them, and the insertion of the oblique muscles at the middle of the eyeball becomes, at that instant, a fixed point of axis, round which the eyeball turns, under the operation of the recti muscles. The conjoined action of the oblique muscles brings the eyeball forward from the socket. The superior oblique muscle, acting alone, does not bring forward the eye, but rolls it so as to turn the pupil downward and towards the nose. The single action of the *obliquus inferior* is the reverse, for it turns the eye again upon its axis, and directs the pupil upward and outward.

There are four muscles in the lower jaw—(1) The *temporal* (*p*, fig. 2, Plate VII.) arise from the flat side of the parietal bone at the side of the head, and the sphenoid and frontal bones in that hollow behind the eye, where they meet to form the squamous suture; they also arise from the inner surface of that strong tendinous membrane which is extended from the jugum or yoke to the semicircular ridge of the parietal bone, at the side of the head. These muscles are pyramidal; their rays converge towards the jugum, their tendon passes under it, and are inserted into the coronoid process of the lower jaw. They pull the lower jaw firmly up, and when we bite they swell on the flat part of the temple, so as to be felt outwardly. (2) The *masseter* (*q*, fig. 1), a short, thick, fleshy muscle, which gives the visible rounding to the cheek, arises from the upper jawbone, and covers the branch of the lower jaw, quite down to the angle, where it is inserted. The parotid gland lies on its upper portion, and the duct of that gland, crossing the cheek, lies over the muscle. It pulls up the jaw, and when we bite it is felt swelling on the back part of the cheek. (3) *Pterygoideus internus* (*r*, fig. 3) arises from the internal flat pterygoid process of the sphenoid bone, and goes inwardly to the angle of the lower jaw. (4) *Pterygoideus externus* (*s*, fig. 3) arises from the outside of the external plate of the pterygoid process of the sphenoid bone, and the adjoining part of the upper maxillary or cheekbone, and is inserted into the neck of the condyle of the lower jaw, and to the upright part of the bone and capsule of its joint. The lower jaw is chiefly moved by these four muscles. The temporal muscle acts on the coronoid process of the lower jawbone like a lever, and raises it. The masseter muscle acts before the temporal muscle on the angle of the lower jaw, and lifts it. The pterygoideus internus, acting within the lower jawbone, balances the action of the masseter on the outside. In biting, holding, and tearing our food with our teeth, these three muscles pull the lower jaw very forcibly upward. The fourth muscle, or pterygoideus externus, going from within, outward from its origin to its insertion, naturally pulls the lower jaw from side to side in chewing, and performs the motion of grinding the food.

Two muscles lie on the fore part of the neck and move the head—(1) *Platysma myoides*, a very thin muscular expansion, spreading over the other muscles of the neck and throat, and extending upward on the lower part of the face and lower jaw. It supports the parts of the neck, compresses the veins.

and, in difficult breathing, forces the blood down into the chest. It is also a muscle of respiration and circulation. (2) *Mastoideus* is the finest and most conspicuous muscle of the body, giving fleshy roundness to the neck, and, rising up when in action, it produces the most beautiful contour in the necks of men and women. It begins by a strong tendon from the triangular position of the sternum or breast-bone, and from the sternal portion of the clavicle (or collar bone), by a broad and fleshy origin, and is inserted into the mastoid angle of the temporal bone, at the side of the head. When the mastoid muscles act in unity on both sides of the head, they pull the head downward, and bring the chin in contact with the chest. When only one acts it pulls the ear down to the shoulder, and by twisting the neck tilts the chin a little up. The disease of this muscle produces wryneck.

BOOK-KEEPING.—CHAPTER II.

BOOKS CONTRIBUTORY AND SUBSIDIARY TO THE CASH-BOOK.

ANY one who has thoroughly mastered the mode of managing the cash-book has acquired "the golden key which opes" the secret mysteries of book-keeping. The leading principle for the arranging and disposing of the accounts of all tradesmanly transactions is involved in it. All giving and receiving implies the relationship of Dr. and Cr. in a real though technical sense. Receiving becomes indebtedness and giving bespeaks acquittance. Each person is Dr. for what he receives, and Cr. for what he gives, supplies, or pays.

A tradesman who gives no credit may conduct his business safely, if careful in his entries, though keeping no other book than the cash-book. The difference between the two sides—Dr. and Cr.—of that one book should, if it has been rightly kept, show, at any time, what he ought to have on hand, and enable him to ascertain the amount of profit made or the amount of loss incurred. All that is really necessary, in this case, is that every business transaction, *i.e.* every operation which changes in the slightest the cash or stock, should be immediately, distinctly, and accurately entered in the cash-book; that the cash-book be regularly and carefully compared with the cash, and that the stock be periodically subjected to review. This might be illustrated by choosing a very simple style of business transaction—say, for instance, a trade in umbrellas and walking sticks.

DR. CASH BOOK. CR.

			£	s.	d.				£	s.	d.
1898. Jan.	4	Capital,	150	0	0	1898. Jan.	4	Paid Davies & Co., for 400 Umbrellas and 300 Walking Sticks,	135	0	0
"	"	To Sales,	13	17	6	"	5	By Rent,	10	3	8
"	5	"	18	11	0	"	"	" Advertising,	1	17	10
"	6	"	12	3	0	"	6	" Fittings,	3	6	8
"	7	"	11	0	6	"	7	" Taxes, 13*s.* 4*d.*; Postages and Circulars, 8*s.* 6*d.*,	1	1	10
"	8	"	17	6	0	"	8	" House Expenses,	4	8	2
"	9	"	15	19	6	"	9	" Wages,	2	2	0
"	11	"	21	18	0	"	11	" Petty Cash,	0	7	3
"	12	"	7	12	6	"	12	" Balance—Cash in hand,	110	0	7
			268	8	0				268	8	0
		Cash in hand, £110 0*s.* 7*d.*									

This exhibits, of course, a very plain series of transactions; but it places clearly before the eye the mode in which the several entries are made, and the manner in which the balance is made out. Supposing, in the meantime, that the transactions are real instead of imaginary, it will be seen that having paid £135 out of his capital of £150, the tradesman had cash on hand on 4th January, 1886, £15. During the period over which the record extends his sales amounted to £118 8*s.*, but out of this he had expended £23 7*s.* 5*d.* This would give him £95 0*s.* 7*d.* of a balance on his cash sales; to this let us add the £15 formerly on hand, and the balance £110 0*s.* 7*d.* is the result, as in the statement given above. But the student may ask how the entries on the Dr. side indicated by the words "To Sales" are got. These are found in a book kept for the purpose, which may take the title of Sales' Book, Cash Receipts' Book, Till Book, &c., at the will of the tradesman. Its form is very simple. A specimen may be readily constructed, *e.g.*

OXENDEAN, *Monday*, 4*th January*, 1898.

1 Umbrella,	£0	12	6
3 Umbrellas at 7*s.* 6*d.*,	1	2	6
5 Walking Sticks at 1*s.* 3*d.*,	0	6	3
7 Umbrellas at 6*s.* 6*d.* (473) to John Steadman,	2	5	6
1 Umbrella 12*s.* 6*d.*, 1 Walking Stick 2*s.* 6*d.*,	0	15	0
18 Walking Sticks as 12 at 1*s.* 4*d.*,	0	16	0
13 Umbrellas as 12 at 8*s.* 6*d.*, to Walter Stark,	5	2	0
1 Walking Stick,	0	1	3
2 Umbrellas at 10*s.* 6*d.*,	1	1	0
3 Umbrellas at 5*s.* 10*d.*,	0	17	6
1 Umbrella,	0	18	0
Total Cash Sales,	£13	17	6

It will be noticed that in some instances the name of the person to whom these goods were sold is jotted down; and in one instance—that of John Steadman—a private mark, 473, is put beside the price. The intention of the note is that if the same person requires to be served again, the special kind of goods may be known and the same price be charged

On the credit side there are other entries which suggest inquiry and require explanation. Such is the entry, house expenses. This item is got from a Household Expenses Book, which may be more or less detailed, according to the taste or wish of the person who keeps it. Of such a book and its entries a specimen may be given.

HOUSE EXPENSES. DR. to CASH.

			£	s.	d.	£	s.	d.
1898 Jan.	4	Bread, 2*s.*; Tea and Sugar, 5*s.*,	0	7	0			
"	"	Potatoes, 8*d.*; Vegetables, 7*d.*,	0	1	3			
"	"	Mutton, 4*s.* 8*d.*; Butter, 1*s.* 6*d.*,	0	6	2			
"	"	Coals, 16*s.* 6*d.*; Washing, 5*s.* 2*d.*,	1	1	8			
						1	16	1
"	5	Pair Boots, 17*s.* 6*d.*; Gas, 8*s.* 3*d.*,	1	5	9			
"	"	Butcher's Bill, 6*s.* 2*d.*; Cheese, 3*s.* 1*d.*,	0	9	3			
"	"	Milk, 1*s.* 8*d.*; Eggs, 1*s.* 4*d.*; Bread, 10*d.*,	0	3	10			
						1	18	10
"	6	Flour, 4*s.* 4*d.*; Meal, 3*s.* 6*d.*,	0	7	10			
"	"	Hand-broom, 1*s.* 8*d.*; Sundries, 9*d.*,	0	2	5			
"	"	Repairing Locks & New Handle, 3*s.*,	0	3	0			
						0	13	3
		Entered in Cash Book, 8th January,				4	8	2

If kept without details, the totals only would be given thus:—

			£	s.	d.
1898. Jan.	4	By Sundries,	1	16	1
"	5	" "	1	18	10
"	6	" "	0	13	3
		Entered in Cash Book, 8th Jan.,	4	8	2

In the Sales' or Till Book, entries are made of all moneys received for goods sold. Columns are often ruled to which the day's total receipts are carried out so as to appear with precise distinctness. This total ought to be entered daily in the cash-book on the Dr. side, as it is a record of money

received. The cash in the till (or otherwise accounted for) should tally with the sum, and if it does not, only the amount of cash actually possessed (or accounted for) ought to be entered in the cash-book.

In large establishments it is customary for each salesman or saleswoman to have a sales' book or till's cheque for him or herself. In these an entry is made of the amount received from each customer served. At the close of the day these require to be all summed up and the total resulting from this addition ought to be represented by the sum in the till (or in charge of the cashier). Such an account would have somewhat of the form undergiven :—

SALES REGISTER, *5th Jan.*, 1898.

	£	S.	D.
Miss Smeal, 5 Umbrellas, 12*s.* 6*d.*, 7*s.* 6*d.*, 18*s.* 6*d.*, 10*s.* 6*d.*, 9*s.* 6*d.*,	2	18	6
Wm. Allardyce, 3 Walking Sticks, 2*s.* 4*d.*, 1*s.* 8*d.*, 4*s.* 6d.,	0	8	6
Wm. Allardyce, 9 Umbrellas, 3 at 7*s.* 6*d.*; 2 at 16*s.* 6*d.*; 4 at 8*s.* 6*d.*,	4	9	6
Miss Temple, 17 Umbrellas at 8*s.* 6*d.*,	7	4	6
P. Roberts, 2 Umbrellas at 12*s.* 6d.; 4 at 7*s.* 6d.; 1 at 8*s.* 6*d.*; 1 at 6*s.* 6*d.*,	3	10	0
Entered in Cash Book, 5th Jan.,	18	11	0

As it is cash received it forms an entry in the Dr. side of the cash-book. The next item on which remark may be required is petty cash. This is a book into which small and trivial sums (with which it would be unwise to burden the cash-book) are taken note of to the most minute expenditure. It acts as a check upon readiness to disburse small outlays unthinkingly, and serves as a reminder of the manner in which many small items of expenditure accumulate and attain bulk. A petty cash account would take a form such as this:—

PETTY CASH. OXENDEAN, *4th Jan.*, 1898.

1898.			£	S.	D.
Jan.	4	One Ball Twine,	0	0	6
"	"	Pens, ink, paper, and pencils,	0	1	3
"	"	Porterage (to J. Steadman),	0	0	9
"	5	Cleaning Windows,	0	0	8
"	"	Pair of Scissors,	0	1	0
"	6	Gum, 1*d.*; Wrapping Paper, 5*d.*,	0	0	6
"	7	2 Pass-books, 4*d.*; Cab-fare, 1*s.*,	0	1	4
"	"	Messenger, 6*d.*; Water-jug, 9*d.*,	0	1	3
		Entered in Cash Book, 11th Jan.,	0	7	3

As it is a record of cash paid, it takes its place among the entries on the Cr. side of the Cash Book. In many instances postages would be included in the Petty Cash Book. In fact, in some businesses, a Trade Expenses' Book would include Advertising, Circulars, Taxes, Fittings, Wages, &c., as well as the petty cash expenditure. Any entries made in such a book would, of course, be transferred at stated times to the Cr. side of the Cash Book, as they record cash paid, which is chargeable against cash received.

In some cases, where money is lent or borrowed, entries are at fixed times made in the cash-book, generally in the inner columns. Borrowed money as *received* is placed on the Dr. side; lent money as *paid* on the Cr. side. In other cases separate folios are set apart for entering such transactions, and sometimes a special book is kept for registering them. In cases where the money is transferred at stated periods by the cashier to the bank, an entry of the amount paid in to the bank is made in the Cr. Cash; and where money is drawn from the bank, an entry to that effect is made in the Dr. Cash. Some tradesmen keep accounts of all transactions with the bank—deposits, withdrawals, cheques, drafts, bills, &c.—in a separate book, and only enter in their business books the results at such stated times as their books are being balanced.

We have now made as plain as we possibly can the most usual mode of keeping the cash-book, with its contributory and subsidiary accounts. It may not be amiss, however, here to place an epitome of what has been said in a series of definite statements, brief and pointed, which may be laid up in the memory, or may be referred to in difficulty, or in preparing for an examination.

1. All moneys *received* must be entered in the Dr. side (left) of the cash-book.
2. All moneys *paid* must be entered in the Cr. side (right) of the cash-book.
3. Each Dr. entry, after writing the date on the margin, begins with the word *To* (expressed or implied).
4. Each Cr. entry, after writing the date on the margin, begins with the word *By* (expressed or implied).
5. Any sum embarked in business is entered on Dr. side—To Stock or Capital in Trade.
6. Any sum deposited in bank for carrying on business is entered on Cr. side—By (inserting the name) Bank, per Receipt or Bank-book.
7. Any money drawn from the bank for carrying on business is entered on Dr. side—To———Bank, per Order (draft, bank-book, &c.)
8. When money is received from or paid to a person the entries should be made respectively on the Dr. or Cr. side—To or By (the full name and correct address of the person, to prevent mistake in the case of dealings occurring with more than one person bearing the same name).
9. Personal expenses (household expenses, trade expenses, private accounts, &c.) and petty cash are entered on the Cr.—By.
10. Goods' sales, cash sales, till-book summations, &c., are entered on Dr.—To.
11. The cash-book balance (if any) must always be an entry on the Cr. side, as more cannot be paid than is received.
12. The greatest possible care should be taken to make the original entries precise and exact. No erasures should be made, and if any error has occurred it ought to be corrected by such an entry as shall not only explain, but nullify the error.

A cashier—indeed, any book-keeper, but especially a young responsible one—ought never, on any account, to stop in the course of making an entry. Whatever the interruption, he should complete the entry on which he is engaged. Nothing is more likely to result in the making of errors than the laying down of the pen to attend to anything during the process of making an entry. It is advisable to pencil-mark the special entry on which the book-keeper is engaged at the moment he stops, if interrupted, especially if balancing cash or making entries from other books.

Cash should be balanced at least daily; and, if there is any deficiency or difference between the cash-book and the cash on hand, the desk should not be left till the discrepancy has been rectified and explained. If it is undiscoverable the cash in hand must be given as the true summation, and such entry made as shall show what the real difference is.

Cash (cash securities or documents transferable into cash) should always be locked away, or otherwise put and kept in a place of absolute security. The carelessness or overtrustingness of one may place temptation in the way of another, or give that opportunity which is the awakener of inclination. It is not enough to be honest ourselves if by our carelessness we tempt others to dishonesty.

It is proper always to count money, no matter from whom you receive it, so as to see that it is right in quantity and in quality; and it is advisable to ask any one to whom money is paid to do the same, so as to prevent any misunderstandings.

Whenever any discrepancy between cash-book and cash is discovered let it be known immediately, that any one who may chance to know may learn that the discovery has been made, and may help in the rectification of the error.

GEOMETRY.—CHAPTER II.

EUCLID'S ELEMENTS—BOOK I. (*Continued.*)

EUCLID in his "Elements of Geometry" treats first of those properties of straight lines and triangles to which the universal experience of man gives assent. He insists on our learning to see what is required in any problem, to foresee all that is implied in it, and to know how to accomplish all the preparatory and previous operations on which the successful

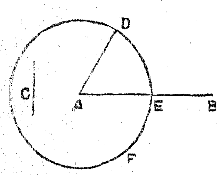
management of each proposition depends. In actual practice when we want to cut off from the greater of two given lines a part equal to the less, we find no great difficulty in managing it in a passable manner, as any one knows who has ever seen a yardstick employed to measure off from a roll of ribbon or tape any number of yards, or who has ever with a pair of compasses measured off any part of a long line to any required length. The geometrician's problem necessitates a finer process, and involves not the demonstration of the mere present practical truth that such a thing can be done, but that it can be done with absolutely unerring exactness anywhere in space and under any circumstances in which two straight lines, of which one at least must be of known dimension as to length, can be (not given only, but) even imagined. The operation is therefore put before the student thus :—

PROPOSITION III. PROBLEM.

From the greater of two given straight lines to cut off a part equal to the less.

The enunciation thus proceeds :—*Data.* Let A B and C be the two given straight lines, of which A B is the greater; [*Quæsitum*] it is required to cut off from A B a part equal to C the less.

Construction.—(1) From the point A, the extremity of the line A B, draw [according to the process shown in Prop. 2] a straight line A D equal to C; then (2) from the point A with radius A D, describe the circle D E F (Postulate 3); and then (3) the straight line A E cut off from the greater line A B is equal to C the less.



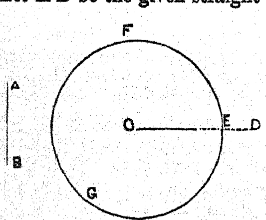
Demonstration. — (1) Because A is the centre of the circle D E F, A E is equal to A D (Definition 15); (2) but the straight line A D is equal (by construction) to C, and therefore A D and C are each of them equal to A E.

Conclusion.—A E is therefore equal to C.

Recapitulation.—Wherefore, from A B, the greater of two straight lines, a part A E has been cut off equal to C the less. Q.E.F.

It is obvious that upon this same principle we can construct at pleasure any scale of lengths. For if A B is made of indefinite length, we cut off from A B a part A E equal to C, from E B another part equal to C, and so on as far as may be required. Such a scale of equal parts may be used as representative values in any enlargement or diminution we may be desirous of making in plans, drawings, &c. On the same principle, too, we may *make a straight line of a given position*, one of the extremities of which remains the same, equal to another given straight line of either greater or less length.

Let A B be the given straight line, and C D the line given in position. It is required to make the distance between C and any other point in the direction C D equal to A B. (1) With centre C and distance A B describe the circle E F G (Post. 3); (2) let E be the point in which the circle cuts the line *in direction* C D; (3) if necessary, produce C D to E (Post. 2); if unnecessary, then C E is equal to A B, retaining the extremity C and the direction C D whether greater or less than C D; (4) because any radius of E F G equals A B (by construction), and C E, being a radius of E F G, equals A B.



Having acquired the power of working these three problems, Euclid regards the student as able to see a geometrical truth, and not only to demonstrate it, but to apply it to further uses, and he tests our real geometrical insight by asking assent to, and demonstration of, five theorems. He constructs (I. i.) with one *given* finite straight line an equilateral triangle, *i.e.* a plane figure, inclosing a space, by three equal straight lines constituting its three sides. A triangle may be regarded as a figure standing on one of its sides, which is on that account called its *base.* The base is not necessarily the line which—as we look at it, in reality or imagination—appears in the lowest position which the geometrician has in view. On the contrary, any one of the sides of a triangle may be, for the time and purpose, regarded as the base. The angle opposite the base is called the *vertex.* When any two sides of a triangle have been named, the remaining side is often designated the base. The *area* of a figure is the amount of space inclosed by its sides. Euclid speedily brings before us the subject of area, and presents to us a theorem, *i.e.* a statement of a truth which is demonstrable through proof derived from truths previously admitted or accepted or formerly proved. His statement is this :—

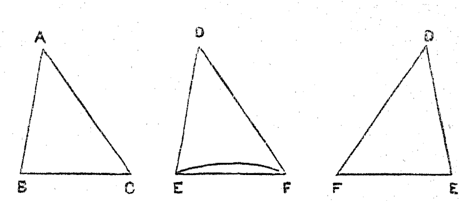
PROPOSITION IV. THEOREM.

If two triangles have (1) *two sides of the one equal to two sides of the other, each to each, and have, likewise,* (2) *the angles contained by those sides equal to one another; then* (1) *their bases or third sides shall be equal,* (2) *the two triangles shall be equal, and* (3) *their other angles shall be equal, each to each, namely those to which the equal sides are opposite.*

Before proceeding to the demonstration of this *theorem,* it may be advisable to remark that *equal* triangles are those whose *sides* and *angles* mutually and respectively coincide, while *equivalent* triangles are those whose *areas* are equal; and this proposition refers only to equal not to equivalent triangles. In geometry, triangles are said to be equal in every respect when they have the three sides and the three angles of the one equal respectively to the three sides and the three angles of the other, and the area of the one equal to the area of the other.

We proceed to the particular enunciation or exposition of the general enunciation of the theorem given above.

Let A B C and D E F be two triangles which have (1) the two sides A B, A C equal to the two sides D E, D F, each to each, *i.e.* A B to D E and A C to D F, and (2) the contained



(or included) angle B A C to E D F; then (1) shall the base B C be equal to the base E F, (2) the two triangles A B C, D E F shall be equal, and (3) the other angles shall be equal, each to each, *i.e.* A B C to D E F, and A C B to D F E.

We indicate now the separate steps of the demonstration.

1. If the triangle A B C be *applied* to the triangle D E F, so that the point A may be on D, and the straight line A B on D E, then the point B shall coincide with the point E, because A B is equal to D E by the terms of the hypothesis.

2. As A B coincides with D E—which has just been proved—the straight line A C shall fall on D F and coincide with it; for (1) the angle B A C is equal to the angle E D F, and (2) the side A C is equal to the side D F; hence the point C coincides with the point F.

3. Now the point B having been shown to coincide with the point E, and the point C with the point F, the base B C shall coincide with the base E F; for if it did not, two lines, B C and E F, would inclose a space, which is impossible (according to axiom 10). Therefore the base B C does coincide with the base E F, and is equal to it.

4. The whole triangle A B C coincides with the whole triangle D E F, and is equal to it; for (by axiom 10) magnitudes which coincide—as they do—with one another, *i.e.* exactly fill the same space, are equal.

5. Also, since the line D E coincides with the line A B, and the line E F with the line B C, the angle A B C shall coincide with and be equal to the angle D E F.

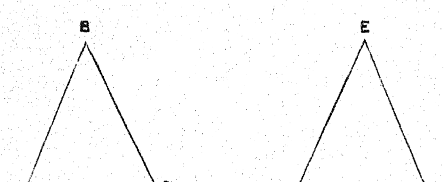
6. And because the side A C coincides with the side D F, and the base F E with the base C B, the angle D F E coincides with, and is equal to, the angle A C B. Thus the remaining angles of the one triangle are equal to the remaining angles of the other triangle, each to each.

7. Wherefore, if two triangles have two sides of the one equal to two sides of the other, &c., Q.E.D.

The demonstration of this theorem involves two new, unasked, and ungranted axioms, involving the ideas of (1) motion and (2) superposition. The former requires it to be allowed that any plane surface, *e.g.* a triangle, may either be, or be conceived to be, taken up and removed from one place to another; the latter, that any plane surface, *e.g.* a triangle, may, when so taken up from the place in which it is, be removed to any other portion of space, point by point, line by line, angle by angle, and laid surface upon surface, provided that no change be made in its form or contents.

It is evident that the term *applied*, used above in the first step of the proof, implies a sense which has not been provided for by previous definition. It includes in its signification the following three processes: (1) the lifting up, really or imaginarily, of the triangle A B C from its *given* place; (2) its removal whole and intact in form and area to the space occupied by D E F; and (3) its being placed (superimposed) point by point, with accuracy and precision, on the triangular boundaries of the space D E F, so as to rest upon these lines and yet be in the same plane with them. It is rather difficult, perhaps, to conceive such a process duly performed. We may illustrate its accomplishment to our minds by imagining a pure glass prism with two equal triangular extremities or ends. These, of course, present equal surfaces to the mind's eye, and may be really brought into juxtaposition by cutting the prism into two parts, and placing the equal triangular ends together. Of course the (ideal) surfaces lying between these two contiguous objects would be two equal and coincident triangles (according to axiom 8), and would fulfil all the conditions of the two triangles with which we have just had to deal in the foregoing proposition.

In the first step of the demonstration it is said that the point A shall *coincide* with the point E, because A B is equal to D E. This reasoning implies that when two lines "coincide," their extremities must also coincide; but it must be carefully remembered, if we would avoid vague or equivocal expressions, that they will only do so when they exactly agree both (1) in inclination or direction, and (2) in extent. Those parts of equal triangles which coincide are called *corresponding* parts.



It would be quite possible to have two triangles having the two sides C A and C B respectively equal to F D and F E, and also equal to one another, and having the angle B A C equal to E D F. In this case they would form an isosceles triangle, and if the proper superposition were made by placing C A on F D and B A on E D, their angles would be proved to be equal, each to each, and so the first part of the proposition 5 might be directly and immediately inferred from this proposition.

It will be observed from the figure that it is a matter of indifference which of the two triangles given as D E F is taken—that which has the side D E to the right or that which has it to the left. The same may be said to be the case in all *plane* triangles, which are (according to the definition) "equal in every respect."

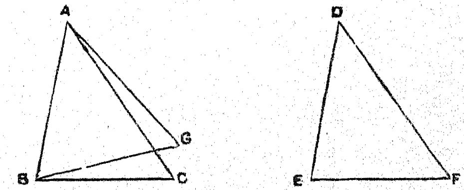
The foregoing *theorem* presents us with the first case of equality between triangles—viz. that of a whole known triangle leading to a knowledge of another triangle of which only two sides and a contained angle are known. Propositions 8 and 24 introduce us to two other cases.

Two of the most important notions which are originated in the mind by the appearances of things are size and shape. We see that figures of different sizes may have the same shape, and figures of different shapes may have the same size. In the latter case geometricians call them equal, in the former similar. Euclid's first idea of equality was that of shape and size combined, and in the earlier portions of the "Elements" that is the signification attached by him to the term equality. He soon, however, found his idea becoming more definite, and as he proceeds employs the word *equal* to signify sameness or coincidence of size only, and introduces the term *similar* to denote sameness in or congruence of form. It is a subsequent result which enables Euclid to prove, as he does in the sixth book, that if figures be made precise and exact in all their various lengths, they will also be accurate in all their relative *directions*, and if made correct and similar in all their relative directions, they must be exact in their relative *lengths*. This conception of similarity—that whatever form can exist of any one size, a precisely similar form may be conceived of as existing elsewhere of that same or of any other size; while in their passage from size to size all lines alter their lengths proportionately and all angles remain the same—implies that whatever figure may be described upon any one line, another figure having the same angles may be described upon any other line.

Professor John Playfair most ingeniously took advantage of this idea to escape from the objection to Euclid's method of solving this (and the eighth) proposition—that it involved the unpostulated axioms of motion and superposition—taken by Thomas Simpson, one of England's most distinguished self-taught mathematicians. Simpson had said that "the laying of one figure upon another, whatever evidence it might afford, is a mechanical consideration, and depends on no postulate." Playfair expresses a conviction that "the demonstrations of the fourth and eighth propositions, as they are given by Euclid, are as certainly a process of pure reasoning, depending solely on the idea of equality as established in the eighth axiom, as anything in geometry." "But," he suggests, "if still the removal of the triangle from its place be considered as creating a difficulty, and as inelegant, because it involves an idea not involved in geometry, this defect may be entirely removed" by adding to Euclid's three postulates this fourth—viz. "That if there be two equal straight lines, and if any figure be constituted on the one, a figure every way equal to it may be constituted on the other." He thinks that "there is no truth whatsoever that is better entitled than this to be ranked among the postulates or axioms of geometry." "On the strength of this postulate the fourth proposition is thus demonstrated" by this cautious, vigilant, and penetrating mathematician.

"If A B C, D E F be two triangles, such that (1) the two sides A B and A C of the one are equal to the two, D E, D F, of the other (see fig. below), and (2) the angle B A C contained by the sides A B, A C of the one equal to the angle E D F contained by the sides D E, D F of the other; [then] the triangles A B C and D E F are every way equal" [*i.e.* (1) they shall have their bases or their sides equal, (2) the two triangles shall be equal, and (3) their other angles shall be equal each to each, viz. those to which the equal sides are opposite]. His process of proof proceeds as follows.

On A B let a triangle be constituted (*i.e.* constructed) every way equal to the triangle D E F; then, if this triangle coin-



cide, it is evident that the proposition is true, for it is equal to D E F by hypothesis, and to A B C because it coincides with it [by axiom 8]; wherefore A B C, D E F are equal to one another [&c.] But if it does not coincide with A B C,

let it have the position A B G; and, first, suppose G not to fall on A C, then the angle B A G is not equal to the angle B A C. But the angle B A G is equal to the angle E D F [by construction]; therefore E D F and B A C are not equal, and they are also equal by hypothesis, which is impossible. Therefore the point G must fall upon A C. Now, if it fall upon A C but not at C, then A G is not equal to A C; but A G is equal to D F, therefore D F and A C are not equal, and they are also equal by supposition, which is impossible. Therefore G must coincide with C, and the triangle A G B with the triangle A C B. But A G B is every way equal [by construction] to D F E, therefore A C B and D F E are also every way equal [&c.], Q.E.D.

In the "Syllabus of Plane Geometry" prepared by the Association for the Improvement of Geometrical Teaching, the following definition, intended to provide a distinct ground in reason for such demonstrations as that with which we have been dealing, is given (Def. 34):—"Figures that may be made by superposition to coincide with one another are said to be *identically* equal; and every part of one being equal to a corresponding part of the other, they are said to be equal in all respects." This is immediately succeeded by the following theorem, which is in essentials that of the fourth proposition, viz. (theorem 5):—"If two triangles have two sides of the one equal to two sides of the other, each to each, and have likewise the angles contained by these sides equal, and of the angles those are equal which are opposite to the equal sides." An indication is given that this is to be solved "by superposition." This is very neatly done in "Elementary Geometry," by J. M. Wilson, M.A., mathematical master of Rugby [under theorem 16], thus, "Let the two sides B A, A C of the triangle B A C be respectively equal to the two sides E D, D F of the triangle E D F, and let them contain the angle B A C = the angle E D F, then will the triangles be equal in all respects. *Proof*—for the angle at A can be conceived (axiom 10, equivalent to Def. 34, quoted above) as placed on the angle D, since these angles are equal, A B lying on D E, and A C on D F; and B and C would then coincide respectively with E and F, since A B = D E, and A C = D F. Hence B C would fall on E F, since these lines would have two points in common, and therefore B C must be equal to E F, and the angles B and C respectively coincide with, and are equal to, the angles E and F, and the area of the triangle A B C is equal to the area D E F."

We have entered into the foregoing somewhat lengthy explanatory details with the aim of making the method of geometrical reasoning easy and familiar to the student. We are anxious to clear every obstacle from his path, and we believe that these remarks must tend to inform the mind and regulate the reasoning powers. We now turn attention to Proposition V.

Every one knows that from the days of old this fifth proposition has been called *pons asinorum*, or "the asses' bridge." It owes this name (1) to its form as given in the diagram, and (2) from its supposed difficulty, which is indeed far more imaginary than real. It stands thus:—

Proposition V. Theorem.

The angles at the base of an isoceles triangle are (1) *equal, and* (2) *if the equal sides be produced the angles on the other side of the base shall be equal.*

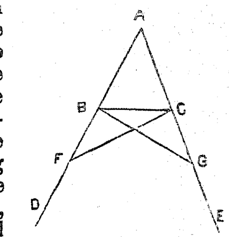
Cor.—Hence every equilateral triangle is also equiangular.

Notice here, first, that the statements set before us are two, one directly affirmed as a fact, viz. "the angles at the base of an isosceles triangle are equal;" and another affirmed to be true on the fulfilment of a certain condition, *i.e.* "if the equal sides of that Isosceles triangle be produced [then] the angles on the other side of the base shall be equal." The angles at the base are internal, the angles on the other side of the base are external.

The second part is made clear at once by our observing in the construction that there are two triangles, B C G and C B F, formed, which precisely fulfil the conditions of Proposition 4, whence we see immediately that the angles at B and C, on the other side of the base B C, are equal. Euclid persists, however, in following a strict and imperious form of demonstration, and his enunciation and proof take the following exquisitely reasoned-out form:—

Particular Enunciation.—Let A B C be an isosceles triangle, of which the side A B is equal to the side A C, and let those equal sides, A B, A C, be produced to D and E. Then (1) the angle A B C shall be equal to the angle A C B, and (2) the angle D B C to the angle E C B.

Construction.—(1) In B D take any point F, (2) from A E the greater cut off (I. 3) A G equal to A F the less, and (3) join F C, G B (*i.e.* draw straight lines which shall join F C and G B respectively). We can now proceed to the demonstration.



1. Because A F is equal to A G (by construction) and A C is equal to B C (by hypothesis), the two sides, F A, A C, are equal to the two, G A, A B, each to each, and they contain the angle F A G common to the two triangles A F C, A G B. Therefore (1) the base F C is equal to the base G B (I. 4), and (2) the triangle A F C is equal to the triangle A G B, also the remaining angles of the one are equal to the remaining angles of the other, each to each, to which the equal sides are opposite, viz. the angle A C F to the angle A B G, and the angle A F C to the angle A G B.

2. And because the whole A F is equal to the whole A G, of which the parts A B, A C are equal; therefore the remainder B F is equal to the remainder C G (axiom 3), and F C has been proved to be equal to G B; hence, because the two sides B F, F C are equal to the two C G, G B, each to each, and the angle B F C has been proved to be equal to the angle C G B; also the base B C is common to the two triangles B F C, C G B, therefore these triangles are equal (I. 4) and their remaining angles, each to each, to which the equal sides are opposite. Therefore the angle F B C is equal to the angle G C B, and the angle B C F to the angle C B G.

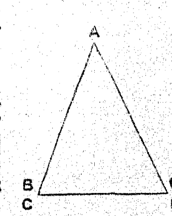
3. Since it has been demonstrated that the whole angle A B G is equal to the whole A C F, of which the parts thereof, the angles C B G and B C F, are also equal, therefore the remaining angle A B C is equal to the remaining angle A C B, and these are the angles at the base of the triangle A B C.

4. And it has also been proved that the angle F B C is equal to the angle G C B, and these are the angles upon the other side of the base.

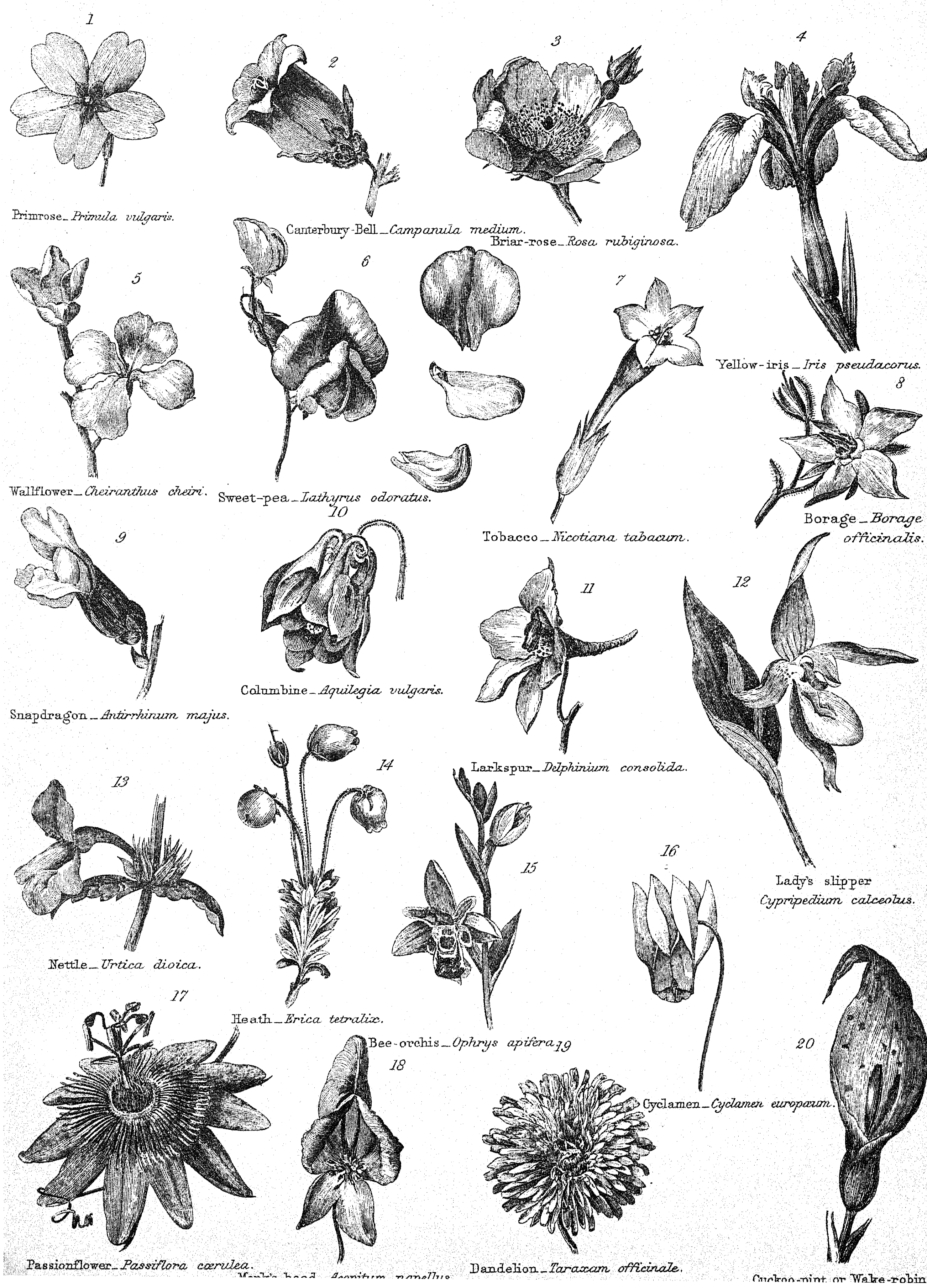
Wherefore it has been proved that the angles at the base of an isosceles triangle are equal to one another, and if the equal sides be produced the angles at the other side of the base are also equal.

Corollary.—Hence it follows that every equilateral triangle is also equiangular, for whichever side is considered as the base every pair of the angles is equal.

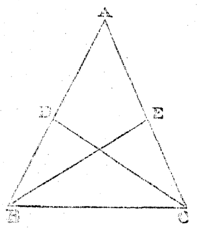
Pappus, an eminent mathematician who flourished at Alexandria about the end of the fourth century A.D., has given a simple solution of the first part of this proposition, viz.—Let A B C and A C B be two isosceles triangles whose sides are respectively equal, that is, conceive two triangles to be coincident. [We might construct such a pair of triangles by drawing on a piece of paper a triangle, and placing a piece of glass over it. The triangle drawn on the paper would be, say, A B C, that formed on the under side of the glass would form A C B.] This would give us two triangles, A B C and A C B, of which the side A B would equal A C, and the side A C would equal A B; therefore two sides of the one are equal to the two sides of the other, each to each, and the angle B A C would equal C A B; hence, according to Proposition 4, the other angles shall be equal, each to each, viz. those to which the equal sides are opposite, *i.e.* A B C = A C B and A C B = A B C.



Proclus, the Neoplatonist (born 412 A.D.) of Constantinople, who wrote a commentary on the first book of Euclid's "Ele-


1
Primrose_Primula vulgaris.
2
Canterbury-Bell_Campanula medium.
3
Briar-rose_Rosa rubiginosa.
4
Yellow-iris_Iris pseudacorus.
5
Wallflower_Cheiranthus cheiri.
6
Sweet-pea_Lathyrus odoratus.
7
Tobacco_Nicotiana tabacum.
8
Borage_Borage officinalis.
9
Snapdragon_Antirrhinum majus.
10
Columbine_Aquilegia vulgaris.
11
Larkspur_Delphinium consolida.
12
Lady's slipper Cypripedium calceolus.
13
Nettle_Urtica dioica.
14
Heath_Erica tetralix.
15
Bee-orchis_Ophrys apifera
16
Cyclamen_Cyclamen europæum.
17
Passionflower_Passiflora cærulea.
18
19
Dandelion_Taraxam officinale.
20
Cuckoo-pint or Wake-robin.

ments," proposed to prove the first part of this proposition—that the angles at the base of an isosceles triangle are equal—by taking on A B, one of the equal sides of the isosceles triangle A B C, a point D, and cutting off from A C a part A E equal to A D. Then joining C D and B E he formed two triangles, D B C and E C B, equal to one another in every respect, of which, therefore, the angle D B C, which is also A B C, is equal to the angle E C B, which also is A C B.



Had Euclid proved, as he might easily have done, Proposition 13 before Proposition 5, the second part of the proof might have been with equal simplicity performed. Proposition 13 is merely a demonstration of the accuracy of definition 10. That proposition sets forth that "the angles which one straight line makes with another straight line upon one side of it are (1) either two right angles, or (2) together equal to two right angles." If, then, in the isosceles triangle A B C, the equal sides A B, A C, are produced to E and F, the angles upon the other side of the base shall be equal to one another; for the angles A B C, C B E are either two right angles or together equal to two right angles. Similarly A C B and B C F are either two right angles or together equal to two right angles. From each of these equals subtract the equal parts A B C and A C B, and their remainders (by axiom 3) will be equal; wherefore the angle C B E is equal to the angle B C F. Angles of this sort are said to be supplementaries of each other, *e.g.* C B E is the supplementary of A B C, and B C F of A C B.

It is particularly necessary, in the consideration of this proposition, to form clear ideas of the *triangles*, which are formed for the purposes of the proof, and of the *angles*, the equality of which requires to be proved. Unless this is done, the letter-signs employed to designate them, which are sometimes similar in their collocation, though different in their signification, may either mislead the reasoner or seem vague to the learner. Having grasped efficiently the precise point attained in Proposition 4 the fifth contains no real difficulty when the mind can perceive the different distinct triangles—which do not always appear separate, and therefore distinct—really present in the figure, and can trace their correspondence one to another.

BOTANY.—CHAPTER II.

HOW TO BEGIN—STRUCTURAL BOTANY—CELLS AND TISSUES OF PLANTS.

Curiosity is a master-force in mind; it is the common form of activity which intellect takes, and it is mainly to the incitement it gives that any real attainments we make in knowledge are due. Few things excite curiosity more than flowers, and almost everybody has a natural liking to know all they can about them. Of course, this general delight derived from the charms of the phenomena of plant-life does not make observation acute, accurate, and exhaustive, and therefore does not imply scientific knowledge. Only give opportunity and direction to such a feeling, however, and the desire to know will achieve its end and attain knowledge. The charm that tempts the mind to research is often quite dispelled when an endeavour is made to make words and terminology take the place of actual experience and personal research. Unfortunately the task of teaching or learning from a book deprives a study of the fine, fresh, healthy invigoration of open air and actual touch and sight. The writer would like his readers to give attention to other leaves than those in which these lessons are to be read, and to look upon what he reads here rather as a set of notes on things seen and handled than substitutes (well illustrated though they are) for personal observation. These pages may be perused by the light of the midnight oil or the gas-jet; but botanical research should be pursued in the light of day in field or glen, in marsh or highway. Get hold of a real plant and observe its parts; get into a habit of examining things in an orderly fashion, of perceiving likenesses and detecting dissimilarities. When out flower-gathering, for instance, look always to the selecting and taking up of good specimens by the root when it is desirable to study the whole plant. Learn also to handle them delicately, so as not to crush, bruise, or injure them, and to examine completely and minutely every organ and every aggregate of organs before removing it from the specimen. It is wise also to acquire the habit of removing each part neatly and in a methodical manner.

Each plant being plastic and reproductive as a whole, has an economy of its own. This is maintained by the functions of its organs. The flower of a plant, speaking generally, with all its apparatus and appendages, when mature as to fruit and seed, is the ultimate stage of its development. Flowers are the organs of fructification and fertilization. In form or in colour (or by both) they have an attraction for every eye. The fixity of their forms and the constancy of their characteristics make them exceedingly valuable, not only as enticements to, but guides in the study of botany. One has only to stroll through field or by wayside lane to recall the experience of spring-tide walks, summer rambles, or autumn wanderings; or, in default of other present means, to look carefully at such a reproduction of forms of inflorescence as is presented in Plate I., to emphasize the fact to his own mind that flowers are almost infinite in their variety, although their parts are wonderfully self-same in place, number, form, colour, proportion, and plan. These parts need not as yet be names to us; they are experiences, and when they get transformed into ideas sight will be changed to insight, and names of them will be welcomed then as registrative marks of what we have seen and know. We shall become quite learned in them when discriminative observation makes us feel the want of them. Let but the noticing eye be engaged, and knowledge having a sound basis on facts will most certainly be gained. The unknown will become the known when eyes and reason are judiciously employed.

If, when we find nestling in the crevices of rocks or settled in the cracks of ruinous masonry, the odorous wallflower (fig. 5), with its buds and blossoms in various stages of development, we pluck a single head from its bunch of florets and examine it, there is much to notice. Its four separate green leaves, outside of and alternating with its four coloured ones; its six thread-like knob-topped filaments (of which two are shorter than the others and have two moist-glands at their base) are not less remarkable than its long two-celled seed-organs, with its short stalk and soft, spongy notched top. Should it be the flower of "a bonny brier-bush" (fig. 3) that catches our attention, its five delicately-coloured and daintily-scented leaves, matching in number the outer green ones, which envelop its tufted threads and its receptacle for seeds, will not fail to keep observation alert. When the primrose's "cup of paly gold" (fig. 1), or that of the cowslip, its partner in the pastures, is looked at with a loving eye, its bell-shaped tubular five-peaked wrapping of green, its salver-formed five-fold coloured leaves, its fivefold filamentous powder-horns, one opposite each of the coloured leaves, and its globose many-seeded central part, might readily suggest to us some hidden secret as lying in these numerical uniformities. How airily graceful is the heaven-blue harebell, drooping so meekly from its slender stem! Its green collarette is formed of five small ornamental leaves; out of them come the fivefold segments of the vegetable bell, and, like all its campanulate congeners, having five tuft-topped threads depending from the base, where lie the seeds of the young plant in a three or a five-celled organ. The bloom of the pea is often seen and is seldom much thought of; yet its papilionaceous, *i.e.* butterfly-shaped (from Lat. *papilio*, a butterfly), flower (fig. 6) has many claims to notice. It is one only of a numerous family, ranging from broom to laburnum. The green leaves which encircle it are five in number and united; but the coloured leaves which it enshrines are separate one from another, and when we pull them off, to examine them better, there seem at first sight to be only four. One of these forms a covering for the others; two of them, one on each side, expand like wings; and two joined together inclose nine dust-bag-tipped threads in one bundle; and a solitary one rising high above the others

makes a tenth, all of which are attached to their green enwrapping leaves, whence the legume or pod proceeds. The three forms of leaf—vexillum (*a*), alæ (*b*), and carina (*c*), as they are called—are exhibited singly on the right of fig. 6.

Never far off need we be at any time from flowers. Buttercups and daisies grow everywhere, and forget-me-not glints out wherever growth is possible, even in the waste places of the earth. It must be a very barren spot where the nettle (fig. 13) does not present the dark-red hue of its inflorescence. Its diverse flower-heads, some showing four and others only two parts, bring us to an interesting question in science, and in the relations of plant and insect life, which may engage us again. Scarcely a piece of moist ground or margin-walk beside a burn or streamlet will fail, in due season, to show conspicuously the gay-coloured beauty of the corn-flag or yellow iris (fig. 4), with which the meadow-crocus, on the one hand, and the cultured gladiolus, on the other, claim kindred. Its sword-shaped, parallel-veined leaves, large and showy, of which three are reflexed and three bent inward, are worthy of attention. Under the inner arched leaves the red-tipped threads are seen, and far down the flower we feel the seeds in a curiously sheathed case. The dandelion's wondrous head of flowers (fig. 19) is one of the most common sights. Its lion-toothed leaves guard its milky-juiced stalk, and its closely-clustered flower-head sits safely thereon until the seed-time has come, when it is succeeded by a round white ball of almost numberless feathers, each of which, as the wind blows, flies off to a new spot, where it may find a place of growth. The stout-stemmed, coarse-looking borage (fig. 8); its blue wheel-like set of leaves, with its tooth-guarded entrance and its cone-topped filaments inclosed in a rough, hairy, five-leaved holder, rises finely from its hairy flower-stalk, and makes itself known among plants of old-fashioned repute as "an increaser of the joy of the mind." The fair columbine (fig. 10), which looks like a miniature brood of young pigeons fluttering to be fed, is pleasant to the eye; so are the fine-tinted and tastely-set cyclamen (fig. 16) or sowbread, and the cosmetic-yielding larkspur (fig. 11), with its five-leaved cap and its four distinct or united coloured leaves. In every one of these, the nearer to nature and the less changed by culture it may be, the botanist finds the riches of wisdom. The florist may train them into a fuller and more striking beauty; but in the simplicity of nature, botany sees the wondrous wealth of design and purpose, and it adds to the charm of the eye the delight of the mind.

So in an unscientific way, imitating (perhaps badly) the sort of untutored mode which, almost without any sensible intention, gets to know something of the varieties of plant-life, and with no special use of technical language, we might go through the whole of the specimens figured in Plate I.—from the nectary flowers of the monkshood (fig. 18) to the legend-noted crown of the passion-flower (fig. 17), with its simple, alternate, variously-lobed flowers, its nail-shaped styles, and its five dust-filled thread-tips; the five-parted holder of the funnel-shaped five-lobed flower of the tobacco-plant (fig. 7); the finely-moulded cups of the heath (fig. 14); the *Arum maculatum* or cuckoo-flower (fig. 20), and the snap-dragon (fig. 9); or the many sorts of orchids—such as the delicate lilac wing-like leaves of the bee-orchis, marked with rich brown and yellow hues, such as vary the velvet-coated humble-bee, and hence deriving its name (fig. 15), or that which bears the pretty poetical name of the lady's slipper (fig. 12)—showing how in its inquiries the mind laid hold of the similarities of things as aids to memory and helps to thought, and how from investigation the notion of organic function in vegetable life arises. But systematic study, when possible, is preferable to desultory thought, and these may all be much more interestingly treated of when we have learned somewhat of plant-life in its real nature, and we come to consider with a distinct aim the purposes and forms of inflorescence. We have all some idea of a root, a stalk, and a flower as parts of plants; but of the four floral whorls which constitute the characteristics of a flower it takes time and thought to gain a correct appreciation. So soon as that is acquired our power of apprehending a plant as possessed of organic life is assured and our interest in botany is secured.

Structural botany arranges in a scientific form all that has come to be known regarding the structures of which plants are composed and the forms of the various organs on which vegetable life depends. By it the building up of the plant from the seed-germ to the perfect plant is explained, and the function performed by each part is made known, from that of the spongiole of the root to the reproductive machinery which operates within the floral whorls that earliest attract man's notice. The uses of each of the parts in the accomplishment of the plan of the whole, and the reaction of the purpose on which a plant is formed on the arrangement and adaptation of the parts, come up for consideration. Here the mystery of growth, that marvellous power of increasing in size, strength, grace, usefulness, and self-evolution, according to a fixed pattern, and to a product which, rising from a delicately enwrapped seed, will ripen, unfurl, mature, and change, so that sunshine and air and earth and water shall be woven together into a mass of mesh-like green of leaf, fern, or moss, of many-hued beauty of flower, into the pliant grace of shrub, or into the majestic height of timber trees.

The various parts of which a plant is composed are termed its *organs*. This term is applied to those external parts which appear distinctly separate even to the most careless eye, as well as to the more delicate apparatus of vegetable life which are unravelled only by dissection. All those parts which are obviously subordinate to the formation of the whole, such as leaves, roots, flowers, fruit, as well as those minute cells, tubes, and fibres of which its internal structure consists, are called organs.

The external organs are sufficiently familiar to every one. They may be grouped under two heads, obviously distinguished from one another by the nature of the functions which they perform. The root, stem, branches, and leaves, with some other smaller appendages to each of them, are formed for carrying on the processes of nutrition, being subservient to the growth of the plant, and are consequently styled the *conservative* organs. The flower and fruit, with their appendages, are intended for performing the function of reproduction, being subservient to the continuation of the species, and are therefore called the *reproductive* organs.

The *conservative* organs are arranged in two sets, one descending into the ground, the *roots*, which spread themselves there for the purpose of sucking up nourishment; and the other set ascending above the ground, the *stem* and branches, with the other parts which they support. This division is not, however, strictly and in all cases correct, for the banyan tree sends down roots from its branches, which by and by fix themselves in the earth. These have still been roots all the time they were hanging in the air. Other plants again, as the bugle, have their stem creeping along the surface of the ground, or even under it, before rising perpendicularly. The distinction above stated is, however, generally correct.

The *reproductive* organs may also be arranged in two series: those which compose the *inflorescence* (Plate I.), that is, the flowers and their appendages; and those which are included under the term *fructification*, that is, the seed and its coverings, which we term the fruit. Here, too, our definitions do not apply in all cases with perfect exactness, for the cryptogamic plants have no flowers nor seeds, but are propagated by *sporules*—little grains which have the same use as, but are totally different in structure from, true seeds.

We shall now devote ourselves to the examination of the internal structure of plants. Before describing the organs, however, we shall look at the nature of the elementary tissues. In these there is great simplicity as compared with the tissues of an animal body, in which each function seems to need an organ specially adapted to perform it; while, in plants, a few simple tissues appear to be all that is required.

Every plant, and every part of a plant, consists of solids and fluids intermixed; the solids being, however, in much greater proportion than in an animal body. Cut a succulent plant across—as the stem of a cabbage—and even with the naked eye a number of minute vesicles or *cells*, exuding fluid, will be seen. All plants originally consist of delicate membranous *sacs*. The cell-wall and the cell-contents (cellulose) form its inclosure and its matter. Various modifications of these original cells form all the organs of plants. These cells are exceedingly small, and are not always appreciable

by the unassisted sight. With the help of a microscope, however, a regular network of hexagonal (six-sided) meshes will be brought into view, smaller and less regular where they surround vessels (tubes), as seen in the accompanying figure (fig. 1). If, on the other hand, the section be made lengthways (as in fig. 2), the cells will appear quadrilateral, compressed, and elongated in the direction of the stem, and still smaller and narrower where they surround vessels. By *vessels* botanists mean tubes, generally very small, sometimes straight, but oftener twisted, spiral, or coiled. In the lowest classes of plants no vessels can be detected, their structure seeming to be altogether *cellular.* We have here in these figures examples of the two *elementary* tissues which we call *fibre* and *membrane,* out of which all other tissues are constructed.

Fig. 1.

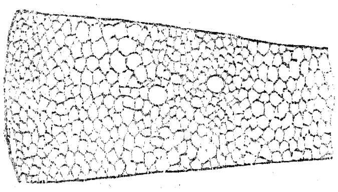
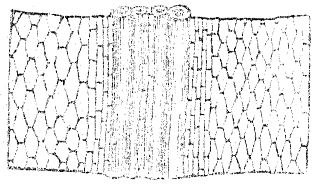


Fig. 2.



In regard to chemical composition plants consist of oxygen, hydrogen, and carbon—the chief constituent elements of starch, sugar, oils, and fats—and in many cases a minute portion of nitrogen. Various vegetable products, differing very much in their sensible qualities, often present to the inquiring chemist a very slight difference in the proportions of their several constituents; so that one is apt to wonder how their taste, smell, and effects on animal bodies are so unlike. As is the case in animal bodies, the several chemical constituents are held together by very slight affinities, apparently as a consequence of being inspired with life.

In the actual anatomy of plants, we find the membranous and fibrous elementary tissues showing themselves under the forms of (1) cellular tissue, (2) woody tissue, and (3) vascular tissue. All these forms are but modifications of simple cells, however different from each other they may become in station, function, or appearance. The cell, which is the original vital unit of plant-life, is at first an exceedingly thin, transparent, bag-like membrane, consisting of (1) the cell-wall, a firm elastic sac; (2) a viscid granular substance—soft, inelastic, albuminoid, and semifluid—in which one or more rounded *nucleations* are found, called protoplasm; and (3) a watery fluid, called cell-sap. A cell is in a state of active vitality when these bright nucleations are seen in the cell-sap. When the cell is developed where it is entirely free from pressure, and is equally nourished on every side, its normal form is more or less rounded, like the cryptogamous red-snow; as, however, cells are commonly developed in confined space, subjected to unequal pressure, and nourished in varying conditions, their actual form is sometimes elliptical, cylindrical, angular, &c., in different plants. So curiously and marvellously are the best energies of life concentrated in these storehouse cell-forms that we are apt to overlook the fact, though it appears before us incessantly, that these atoms of a world invisible to the naked eye are munificently endowed with a wealth of vitality which, nourished by the chemistry of earth, air, and light, become flower, shrub, or tree, each of which contains within it the power of perpetual renewal.

All organs are developed from a rudiment which consists of nothing but cellular tissue; for every seed is at first just an aggregation of cells, though after its vital principle has been excited, and it has begun to grow, woody fibres and vessels are generated in abundance. All forms of tissue are developed from the simple cell, and are consequently but modifications of it. The simplest plant we know, the yeast plant (*Torula cerevisiæ*) for instance, is merely a minute oval vesicle, from the 400th to the 800th of a line in diameter, inclosing within it an albuminoid semifluid. It grows by the giving out of granules, which divide and form new cells, until a plant-body is formed called cell-tissue. All plants consisting of cell-tissue form separate cells—pollen grains or spores—in which this energy of vitality is stored, capable of taking a new departure and of taking on an individual form. Cell-tissue is the parent form of all others. They may appear as cell-masses, cell-rows, cell-layers, cell-bundles, or cell-groups, and they result in tissues, cellular, woody, vascular, and epidermal, of each of which we may now advantageously try to gain an idea.

Cellular tissue consists of little sacs or vesicles, of various shapes, adhering together in masses composed of membrane and fibre, transparent and colourless; its colour, when it appears to have any, being caused by something contained within it. If a thin slice of the pith of the elder, or any similar plant, be examined with a sufficient magnifying power, it will be found to have a sort of honeycomb appearance, as seen in fig. 1, consisting of cavities separated by partitions. These little cavities are the sacs of cellular tissue, and the partitions are caused by the adhesion of their cell-walls. These sacs are destitute of any perforations or visible pores, so that each is closed up from its neighbour; though, as they have the power of filtering fluids rapidly (in a manner to be explained hereafter), it is certain that they must abound with invisible pores, and are not impermeable, as if made of glass. The limits of colour are often very accurately marked in flowers, as in the stripes of tulips and carnations; this could not be the case if their cellular tissue were freely perforated, for in that case the colours would necessarily run together.

The cellular tissue, as has been said, is transparent and colourless, or at most only slightly tinged with green. The clear satiny lustre which the surfaces of many rich flowers exhibit, depends on this colourless quality. In some, as in species of the garden balsam, a brilliant scarlet cell will be seen in the midst of a colourless flower-leaf; and if it be properly examined, it will be found filled with a colouring matter of which the surrounding cells are destitute. These cells are developed, in some cases, with great rapidity. Lindley says he has seen the *Lupinus polyphyllus* grow in length $1\frac{1}{2}$ inch a day, and that another observer saw the leaf of the *Urania speciosa* lengthen from $1\frac{1}{2}$ to 3 lines per hour, and even as much as 4 or 5 inches per day. This may be computed to equal the development of at least 4000 or 5000 sacs in the hour! These sacs or cells are always very small, but are exceedingly variable in size. The largest are generally found in the gourd tribe, or in pith, or in water plants; and of these, some are as much as $\frac{1}{30}$ of an inch in diameter, their ordinary size being about $\frac{1}{100}$ or $\frac{1}{300}$, and sometimes not more than $\frac{1}{1000}$. These microscopical measurements must all, however, be taken with some degree of allowance.

It would appear that the spheroid (fig. 3) is the original form of the cell, and that it becomes altered in varied situations, thus accommodating itself to its neighbours, and to the uses for which it is designed, so as to be oblong (fig. 4) or elongated (fig. 5). If we suppose a piece of cellular tissue,

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

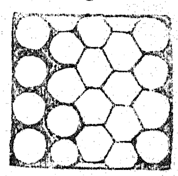


Fig. 7.

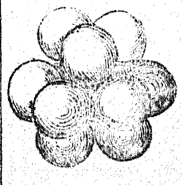


Fig. 8.

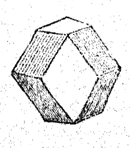
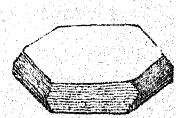


Fig. 9.

Fig. 10.



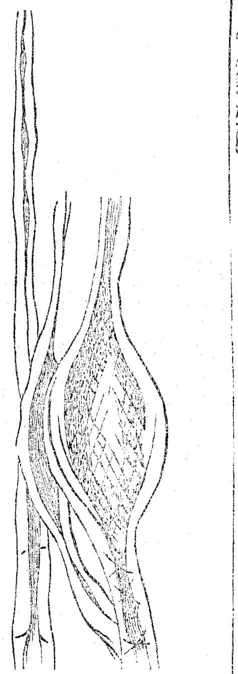
consisting of rounded cells, to be compressed, the cells will plainly become, as in a honeycomb, hexagonal (fig. 6), because six equal circles can touch a seventh which is in the centre. Of course, when the cells are unequal this regularity is lost. Instead of looking at their cut edges, and considering them as circles or hexagons, if we take them to be spherical sacs or cells, we will find that one cell may become the centre round which twelve others can be ranged, of equal size, all in contact with one another (fig. 7); and if these be subjected to pressure, each sphere will be compressed into a *dodecahedron*, or figure with twelve sides and eighteen angles, of which three varieties are given—the rhomboidal (fig. 8), the elongated (fig. 9), and the flattened (fig. 10).

Many vegetable anatomists consider *woody tissue* to be a mere form of cellular tissue in an elongated state. Generally cellular tissue is brittle, and has little or no coherence; woody tissue has great tenacity and strength, whence its capability of being manufactured. Flax is an annual fragile-looking plant, whose purplish blue flowers spring from a slender fibrous stem (see figs. 11, 12). The fibrous rind of this hollow

Fig. 11.

Flax Plant.

Fig. 12.

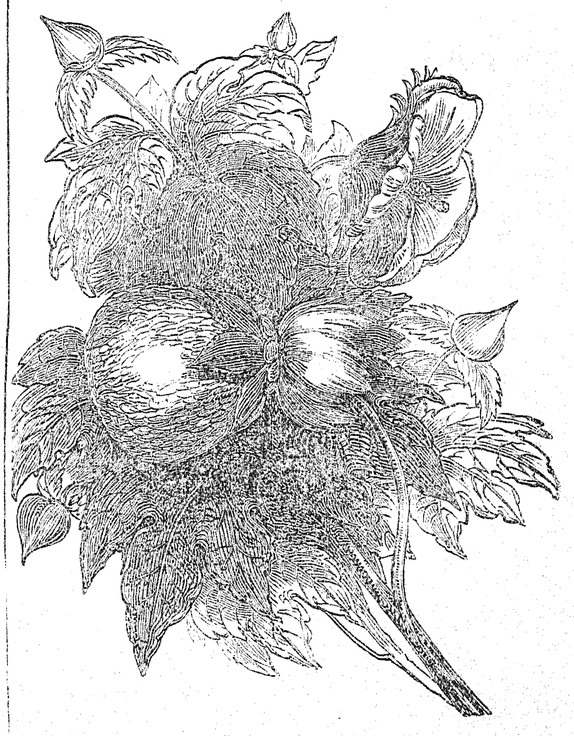


Fibres of Flax (magnified).

stalk supply the filaments which are of so much importance in textile manufacture. Hemp, which so wonderfully adapts itself to diversities of climate, has its pith inclosed in a stem, the tender brittle substance of which furnishes the reed, boon, or shove of hemp, and is retted like flax and so made available for manufacturing purposes. Everything prepared from flax, hemp, and the like, is composed of woody tissue. Cotton (see fig. 13) is, on the contrary, a shrubby perennial plant, with large showy flowers, growing singly upon stalks in the axils of the leaves. The flowers are yellow, they quickly fade, and are followed by the fruit or "boll" containing numbers of black oblong seeds nestling in a white cradle of cotton. It is cellular tissue, and bears no comparison, as to strength, with either flax or hemp. Woody tissue consists of fibres, and the fibres, when separated for making thread, are by no means in a state of final separation. Each of the finest that meets the eye is in reality a bundle of others, often six times finer than the finest human hair. Even those very finest ones are considered to be really tubes varying from $\frac{1}{150}$ to $\frac{1}{3000}$ of an inch in diameter. Woody tissue forms a considerable share of the woody part of all plants; it gives stringiness to bark, and tenacity to the veins of leaves. There can be little doubt that it consists of compressed cells. Its chief chemical constituent is carbon, which it yields plentifully, on being charred.

Vascular tissue consists of small membranous tubes or vessels, having the power of transmitting the fluids of the

Fig. 13.



plant for its nutrition. We can easily have an idea of the mode of their formation, if we suppose a series of elongated cells to open into one another, as seen in the accompanying fig. 14. These vessels are generally spiral, sometimes one vessel running by itself (fig. 15), with greater or less intervals between its turns, and sometimes two (fig. 16), three, or four (fig. 17) running together. Through these *spiral vessels*, and probably also through the tubes of the woody tissue, the fluids on which the plant is nourished are drawn up from the ground. They then pass into the leaves to be exposed to the air, where they give off a portion of oxygen, and absorb a portion of carbon, and afterwards descend in the true sap-vessels, which run in the inner bark, for the purpose of nourishing the plant and causing it to grow, that a new layer may be added to the stem over the old, just beneath the bark. Thence, when

Fig. 14.

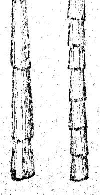


Fig. 15.

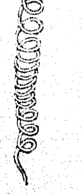


Fig. 16.

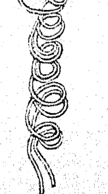
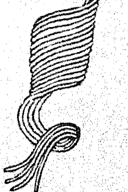


Fig. 17.



growth is necessary elsewhere, the sap arrives at the place by permeating the cellular tissue of the *medullary rays*, a distinct part of wood, the nature of which will be explained in a future chapter. The sap is constantly flowing through a plant, except during the time of frost; but its flow increases in spring, becomes very copious in summer, and in

the autumn gradually diminishes. Although plants have not a circulation like that of animals—the same fluid constantly departing from, and returning to, a central point—still their fluids have a motion which often presents extreme rapidity. This is proved by the great quantity of water which they perspire—all of which must be replenished by a new supply, passing in rapid motion from the roots along the vascular and woody tissues. A young vine-leaf is said to perspire so copiously that, if a glass be placed next its under surface, it is presently covered with dew, which in half an hour trickles down in ooze. Hales found a sunflower lose 1 lb. 4 oz., and a cabbage 1 lb. 3 oz., in a day, by perspiration.

The *vital vessels* (fig. 18), analogous to our arteries, which are situated in the inner bark, close to the wood, present a different appearance from those in which the sap rises; they communicate sideways, or *anastomose*, frequently with one another; and in some plants (with the help of the microscope) the juices may be seen in currents consisting of a succession of globules flowing very rapidly through them.

Fig. 18.

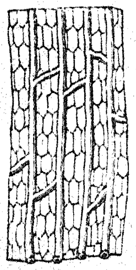
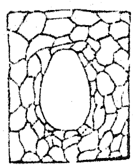


Fig. 19.



The *cells* of plants are filled with juices, which distend them and make them stiff and firm; and it is from the evaporation of these juices, of which no new supply is provided, that the leaves and stem droop a few hours after being plucked. The stiffening effect of the water again distending them, is seen in a bouquet of flowers, which will droop before they have been got home from a walk, but revive and hold themselves up soon after their stems have been put into a glass of cold water. These juices have particular qualities, as colour, taste, and smell, distinguishing them in different vegetables. But in addition to these, many plants have *proper vessels*, or *receptacles* of secretion, in which particular fluids are contained, filled with the *proper juice* of the plant, *i.e.* with its sap altered to the state which is peculiar to the particular species producing it. They seem generally to be formed by the dilation of one cell at the expense of its neighbours, which it compresses, as the little oblong or round cysts in the rind of the lemon and orange (fig. 19), which every one has seen and knows to contain a pungent and inflammable essential oil. Many of the plants which grow in water have cells of this kind filled with air, which serve the purpose of swimming-bladders, enabling their stems to float resting on the surface of the water, so that their parts of fructification may be exposed to the air.

THE GERMAN LANGUAGE.—CHAPTER II.

ARTICLES—THEIR NATURE, USES, AND INFLEXIONS.

The article singles out and sets before the mind some one object (or more) out of a whole class; or it indicates the consideration of a whole class as distinguished from other classes. This recognition may be (1) more or less definite; or (2) entirely indefinite. From its nature, the indefinite is used only in the singular; the definite can be used either in the singular or the plural. As every noun or word used as a noun is written and printed in German with a capital letter, the article is practically very useful to the learner, in marking, as it does, the gender of each.

In German there are two articles—(1) the *definite*, and (2) the *indefinite*.

Each article is declined by four cases, viz.—nominative, genitive, dative, and accusative. The accusative singular of the feminine and the neuter gender, and the accusative plural, are always like the nominative. The definite article has a plural, but only one word for the three genders. The indefinite has, of course, no plural.

	DEFINITE ARTICLE. Singular.			Plural.		INDEFINITE ARTICLE. Singular.			
	Mas.	*Fem.*	*Neut.*	*M. F. N.*		*Mas.*	*Fem.*	*Neut.*	
N.	der	die	das	die,	the	ein	eine	ein,	a
G.	des	der	des	der,	of the	eines	einer	eines,	of a
D.	dem	der	dem	den,	to the	einem	einer	einem,	to a
A.	den	die	das	die,	the	einen	eine	ein,	a

In the nominative case of the singular number the definite article has distinct terminations for the three genders, viz.—masculine, feminine, and neuter. Thus it indicates the gender of the substantive before which it stands—*i.e.* by the article it is seen whether the substantive is masculine, feminine, or neuter in gender.

The terminations of the indefinite article for the masculine and neuter are the same in the nominative case, and they therefore do not, in the same manner, indicate the gender, as may be seen in the following examples:—

Masculine, der Mann, the man; feminine, die Frau, the woman; neuter, das Kind, the child (definite article).

Masculine, ein Mann, a man; feminine, eine Frau, a woman; neuter, ein Kind, a child (indefinite article).

The use and value of this remark will appear when we reach the declension of adjectives and pronouns.

Ein, eine, ein, in the signification of *one*, *some one*—like *quidam* or *aliquis* in Latin—is preceded by the definite article, and is thus declined:—

	SINGULAR. *Mas.*	*Fem.*	*Neut.*	PLURAL. *M. F. N.*	
N.	der ein=e	die ein=e	das ein=e	die ein=en,	the one.
G.	des ein=en	der ein=en	des ein=en	der ein=en,	of the one.
D.	dem ein=en	der ein=en	dem ein=en	den ein=en,	to the one.
A.	den ein=en	die ein=e	das ein=e	die ein=en,	the one.

The definite article der, die, das is often used as a demonstrative adjective pronoun—which it originally was—with the signification of *this*, *these*; and the demonstrative pronoun is sometimes used in place of the definite article, the declension of which, as will be seen in the following paradigm, it very closely follows:—

	SINGULAR. *Mas.*		*Fem.*	*Neut.*	PLURAL. *M. F. N.*
N.	d=ieſ=er,	this	di=eſ=e	d=ieſ=es.	di=eſ=e.
G.	d=ieſ=es,	of this	d=ieſ=er	d=ieſ=es.	d=ieſ=er.
D.	d=ieſ=em,	to this	d=ieſ=er	d=ieſ=em.	d=ieſ=en,
A.	d=ieſ=en,	this	di=eſ=e	d=ieſ=es.	di=eſ=e.

The definite article is also often used as a relative pronoun, *e.g.* der Hut den ich ſah, the hat which I saw.

It may also be noted that the following possessive and indefinite pronouns are declined in the singular, in precisely the same manner as ein, viz.—mein, my, dein, thy, ſein, his, its, kein, none.

	SINGULAR. *Mas.*	*Fem.*	*Neut.*	PLURAL.
N.	ein	ein=e	ein.	ein=e.
G.	ein=es	ein=er	ein=es.	ein=er.
D.	ein=em	ein=er	ein=em.	ein=en.
A.	ein=en	ein=e	ein.	ein=e.

All that is necessary for the declension of these words is to place successively the initial letters m, d, ſ, and k before the pronoun as here declined.

The articles play a far more prominent part in German than in English. There are in the former but few instances in which they may be omitted, a great many in which they must be employed, and scarcely any in which their use would be entirely improper. The following regulative observations should, therefore, receive attention:—

I. Proper names are generally used without the article, as already sufficiently defined, but (1) rivers, seas, lakes, mountains, and forests; and (2) names of months, and those of countries and towns which are of the masculine or feminine gender, take the definite article. If the proper name is qualified by an adjective the article precedes the adjective.

II. Common names used as titles before a proper noun take no article.

III. Names of materials are not preceded by an article, as Salz, salt, unless (1) when it is desired to distinguish one kind from another, as die Salze, the (kinds of) salts; or (2) when the entire quantity of anything taken altogether is meant, as das Wasser ist klar, water is clear.

IV. The whole genus of anything expressed by a common name, a noun used collectively, has always the definite article before it, as der Mensch ist sterblich, man is mortal.

V. Abstract nouns (unless when they signify actions) require no article.

VI. In many common phrases having an adverbial force, the article is omitted between the preposition and the noun, *e.g.* zu Hause, at home; bei Tische, at table.

VII. The definite article is frequently used with names, (1) of persons, (2) of materials, and (3) abstract substantives, to indicate a *case*, especially the genitive and dative; as der Tod des Sokrates, the death of Socrates; Er zieht Milch dem Wasser vor, he prefers milk to water; Höre die Stimme der Vernunft, listen to the voice of reason; Brutus tödtete den Cäsar, Brutus killed Cæsar.

VIII. The following nouns, used in a general and abstract sense—die Natur, nature, das Leben, life, der Tod, death, der Zufall, chance, der Himmel, heaven, die Erde, earth, and the adjective meist, most, always have the article.

IX. The article is repeated before nouns of differeut genders, *e.g.* Ich habe das Buch, die Feder, und den Bleistift auf dem Tische gelassen, I have left the book, the pen, and the lead pencil on the table.

X. The article is omitted before nouns used in a partitive sense, *i.e.* as indicating a part of a number or quantity of things, *e.g.* Geben Sie mir Papier, Federn, und Dinte, Give me paper, pens, and ink.

XI. Articles agree with the nouns they qualify in gender, number, and case, *e.g.* der Vater, die Mutter, das Kind.

EXERCISE.—(1) Put the proper definite article, according to the gender (as indicated), before each of the following nouns. (2) Put the proper indefinite article before such of these nouns as it may rightly precede, according to the gender indicated. (3) Write out a correct copy of these nouns, with the proper articles before them, and the translation of the same into English, and commit them to memory, as part of a useful German vocabulary.

Adler,	*m.*	eagle.	Jahr,	*n.*	year.	Sand,	*m.*	sand.
Ball,	*m.*	ball.	Kalb,	*n.*	calf.	Gras,	*n.*	grass.
Citrone,	*f.*	citron.	Land,	*n.*	land.	Tag,	*m.*	day.
Ding,	*n.*	thing.	Mast,	*m.*	mast.	Hut,	*m.*	hat.
Ende,	*n.*	end.	Name,	*m.*	name.	Vater,	*m.*	father.
Feld,	*n.*	field.	Ofen,	*m.*	oven.	Wind,	*m.*	wind.
Gold,	*n.*	gold.	Perle,	*f.*	pearl.	Art,	*f.*	axe.
Held,	*m.*	hero.	Quelle,	*f.*	well.	Sylbe,	*f.*	syllable
Insel,	*f.*	isle.	Ring,	*m.*	ring.	Salz,	*n.*	salt.

(4) Add to these all nouns quoted in the examples given in this chapter, and having placed the proper articles before them, commit them also to memory.

CHAPTER III.

DECLENSION OF NOUNS.

GERMAN nouns take special forms to indicate the different relations they hold (1) to each other and (2) to the other words in a sentence. These different forms are called *cases* (from Lat. *casus*, a fall), and are intended to denote the chief positions into which things fall (as it were) under the notice of the mind in thinking. (1) The first case is that in which the noun represents that which is laid down before the mind as the *subject* (Lat. *subjectus*, placed under) of (*a*) thought and (*b*) discourse. As such it is named, and this case is therefore called the *nominative* (Lat. *nominatus*, named). (2) Everything may be regarded as resulting from, belonging to, or made of something else. The word bearing this relation to another is said to be in the *genitive* (Lat. *genitus*, originated) or possessive case. (3) A third relation is that of receiving benefit or hurt from, or being in some respect the receiver of influence advantageous or disadvantageous from another, and this is called the *dative* (Lat. *datus*, given) case. (4) Looking on things as the direct object of thought, feeling, or action, the words by which they are named in this relation are put in the *objective* or *accusative* (Lat. *accusativus*, having attributed to one [something]) case. These four cases constitute the declension (Lat. *declensio*, a falling) of a noun, and the setting forth in correct arrangement and proper termination of these cases in the singular and the plural is called declining a noun.

Declension consists in making such changes (1) in the terminations of nouns, and (2) modifications of the stem-vowels of nouns, as serve to indicate their grammatical relations. There are three forms of declension, viz.:—

I. The ancient or strong form, the words in which are almost all masculine and neuter, and many of which modify the vowel of their radical or root part in the plural.

II. The modern or weak form, the words in which are almost all feminine, take n, if any addition is made in the cases, singular and plural, and do not modify the vowels.

III. The mixed declension conveniently includes (1) words which follow the strong declension in the singular and the weak in the plural, or (2) are otherwise *irregular*.

In each declension there are two *numbers* (1) singular and (2) plural, and four *cases*—the nominative, genitive, dative, and accusative.

As regards these cases the following general observations may be made, as holding good without reference to the different systems of declension advocated or approved by different grammarians:—

In the strong declension the nominative and accusative singular are alike.

Feminine nouns are all alike in the cases of the singular, and all the cases of the plural are alike. In feminine forms ending in in the n is doubled before taking the plural case-endings.

The genitive singular of all neuter and of most masculine nouns ends in s.

There is no vocative or ablative case. The nominative is used for the former.

The nominative, genitive, and accusative plural are alike in all nouns.

The dative plural, in all declensions, ends in en or (after l and r) in n.

In dictionaries the *genitive singular* and *nominative plural* are generally marked as follows:—

Vater	(— s.	*plur.*	Väter.
Baum	(— es.	*plur.*	Bäume.
Knabe	(— n.	*plur.*	— n.

(The student ought to look carefully to this point in making his choice of a dictionary.)

In high German, forms of declension and case-endings were numerous and varied; because, being like Latin, without a definite article, the Germans required to make the relations of case capable of clearly indicating distinctions of meaning. When, however, following the practice of the age, the employment of the demonstrative as an article became common in the thirteenth century, they found it possible greatly to reduce the number of the changes made in their nouns. The use of (1) the terminal vowels a, ai, eo, i, o, and u, and (2) of the consonantal terminations j, m, ns, and v became possible, and grammatical economy, in combination with the natural law of euphony, enabled them greatly to diminish the complexities of their declensions.

There prevails in German a soft and almost mute e in the affixes and terminations of words. This e, when rightly managed, has a fine mellow, harmonizing effect when introduced where many strong syllables come together in close succession, and imparts rhythmical sweetness to what might otherwise be harsh phraseology. Hence, when nouns or adjectives have not naturally a soft e, or a syllable containing one, such a syllabic termination is adopted to form the plural, as—Nominative singular, Stamm (lineage), genitive singular Stammes, nominative plural Stämme, dative plural Stämmen, unless when this would give rise to a dactyl (¯ ˘ ˘), and involve a sing-song sameness at the end of a word, *e.g.* der Namen or Name (name) would naturally form genitive Namenes, but appears as Namens; so Willen (will), instead of

Willenes, makes Willens, &c. Nothing except the consonants n or s (as the case may be) is added to nominatives ending in a soft e, or a syllable containing it. To nouns which would otherwise yield harsh successions of syllables, because they have not in their last syllable a soft e, a euphonic e is added before n or s, and in the plural (sometimes) the flowing liquid r is added to give a finer rhythm to the termination; hence such forms as—Nominative singular, Arm (arm), genitive singular, Armes, nominative plural, Armen; nominative singular, Kind (child), genitive singular, Kindes, nominative plural, Kinder, dative plural, Kindern.

These observations are explanatory of peculiar phenomena in declension, but do not form a shorthand mode of avoiding the task of learning the declensions of nouns, which ought to be gradually but carefully proceeded with by aid of the directions which follow.

FIRST DECLENSION.

I. The ancient or STRONG DECLENSION is so called because the changes made in it to indicate the cases of the nouns comprehended under it, are not external only, but often internal as well. It not only takes a greater number of terminations than the weak declension, but it also very frequently imposes on the pure vowels a, o, u of the radical part of the noun a change into ä, ö, ü, called by the Germans der Umlaut (the modification). Declension may therefore be said, as it were, to enter into the inner life of these words, and so to change them very powerfully. Of the strong declension there are three classes—

1. The ORDINARY form, comprising those nouns which form the genitive in es and the dative in e—

SING. MAS.		PLURAL.
N. der Sohn,	the son,	die Söhn-e.
G. des Sohn-es,	of the son,	der Söhn-e.
D. dem Sohn-e,	to the son,	den Söhn-en.
A. den Sohn,	the son,	die Söhn-e.

2. The CONTRACTED form, comprising those nouns which form the genitive in s—

SINGULAR.		PLURAL.
N. der Vogel,	the bird,	die Vögel.
G. des Vogel-s,		der Vögel.
D. dem Vogel,		den Vögel-n.
A. den Vogel,		die Vögel.

3. The EXTENDED form, comprising those nouns (usually neuter) to which, in the plural, an r is added to the inflexional e—

SING. NEUT.		PLURAL.
N. das Bad,	the bath,	die Bäd-er.
G. des Bad-es,		der Bäd-er.
D. dem Bad-e,		den Bäd-ern.
A. das Bad,		de Bäd-er.

The first (*ordinary*) class comprises chiefly masculine and (some) neuter nouns of one syllable: the addition of es and e is really intended to avoid the abrupt and unpleasant sound which would often be made by the addition of s alone. They may be classified thus:—

Those masculine and neuter nouns which, in the nominative, end in—

(1) An s-sound, or one in which the sound of s predominates—*i.e.* s, ß, sch, st, x, z, or tz, as das Haus, house; der Schuss, shot; der Wunsch, wish; der Rest, remainder; das Obst, fruit; der Schatz, treasure; das Holz, timber; der Arzt, the physician.

(2) The vowels i or u, and the mutes b, p, d, t, th, f, v, g, h, ch, k, or ck, as der Korb, basket; das Brod or Brot, bread; das Zelt, tent; der Muth, courage; der Hof, courtyard; der Tag, day; der Schuh, shoe; der Teich, pond; der Bock, he-goat. These nouns *may* elide e in the genitive and dative.

(3) A liquid (*i.e.* l, m, n, r) if (*a*) primitive nouns or compounds formed by the affixes sal and niss; (*b*) foreign nouns having the tonic accent on the last syllable, or compounds formed by the terminations ment, tiv, scop, and (in mineralogy) it. These all take a plural in e, without other inflexion than the addition of n to the dative.

To the second (*contracted*) class belong most masculine and some neuter nouns of two or more syllables; the addition of e as well as s to the genitive would be adding a syllable which is not needed for euphony.

The nouns of this class may be arranged thus:—

(1) Derivative masculine and neuter nouns ending in el, em, en, er—which never have the accent on the last syllable.

(2) Neuters ending in e and diminutives ending in chen and lein. Those which terminate in e, el, en, and er have their nominative plural like the singular.

(3) Letters and words used as nouns (which do not usually take a plural).

(4) The following masculine nouns, which may have n in the nominative singular, but are always declined as if they were derivatives in en (gen. Buchstabens, Friedens, &c.):—

der Buchstabe,	the letter.	der Glaube,	the belief.
der Friede,	the peace.	der Name,	the name.
der Funke,	the spark.	der Schade,	the damage.
der Gedanke,	the thought.	der Wille,	the will.

These formerly terminated in en in the nominative (der Namen, der Willen), and are often even now met with in this form; they do not modify their vowel in the plural.

These two words, der Schmerz, the pain, and das Herz, the heart, take in the genitive des Schmerzens or Schmerzes, des Herzens; in the dative dem Schmerze, dem Herzen or Herze; and in the accusative den Schmerz, das Herz.

To the third (*extended*) class belong those nouns which form their plural in er, the majority of them being neuter words of one syllable.

These are (1) all substantives ending in thum, as der Irrthum, the error (die Irrthümer).

(2) The following masculine monosyllables:—

SINGULAR.		PLURAL.
der Geist,	the mind,	die Geister.
der Gott,	the God,	die Götter.
der Leib,	the body,	die Leiber.
der Mann,	the man,	die Männer.
der Ort,	the place,	die Oerter.
der Rand,	the edge,	die Ränder.
der Strauch,	the shrub,	die Sträucher.
der Wald,	the forest,	die Wälder.
der Wurm,	the worm,	die Würmer.

(3) These neuters among others—

SINGULAR.		PLURAL.
das Band,	the ribbon,	die Bänder.
das Blatt,	the leaf,	die Blätter.
das Buch,	the book,	die Bücher.
das Dach,	the roof,	die Dächer.
das Dorf,	the village,	die Dörfer.
das Ei,	the egg,	die Eier.
das Glas,	the glass,	die Gläser.
das Haus,	the house,	die Häuser.
das Huhn,	the fowl,	die Hühner.
das Kalb,	the calf,	die Kälber.
das Kind,	the child,	die Kinder.
das Kleid,	the dress,	die Kleider.
das Lamm,	the lamb,	die Lämmer.
das Land,	the land, country,	die Länder.
das Licht,	the light, candle,	die Lichter.
das Loch,	the hole,	die Löcher.
das Nest,	the nest,	die Nester.
das Schloß,	the castle, lock,	die Schlösser.

(4) To this list add the following compounds, der Bösewicht, the villain, der Vormund, the curator, and the following neuter nouns with the augment ge:—

SINGULAR.		PLURAL.
das Gemach,	the apartment,	die Gemächer.
das Gemüth,	the mind,	die Gemüther.
das Geschlecht,	the sex,	die Geschlechter.
das Gesicht,	the face,	die Gesichter.
das Gespenst,	the spectre,	die Gespenster.
das Gewand,	the garment,	die Gewänder.

A few words, including those of one syllable ending in r only take e in the plural, *e.g.* das Jahr (the year), die Jahre.

SECOND DECLENSION.

II. The modern or WEAK DECLENSION includes (almost) all the nouns feminine, and only a few of the masculine gender.

1. Feminine nouns are (for the most part) undeclined in the singular form, and have their plural in en—

	SINGULAR.		PLURAL.
N.	die Frau,	the woman,	die Frauen.
G.	der Frau,		der Frauen.
D.	der Frau,		den Frauen.
A.	die Frau,		die Frauen.

(1) Nouns ending in e, el, er only add n, *e.g.* die Schwester (sister), die Schwestern.

(2) Nouns in in, formerly inn, double the final n before adding en, *e.g.* die Königin (queen), Königinnen; Heldin (heroine), Heldinnen; Göttin (goddess), Göttinnen.

(3) These two nouns are invariable in the singular, but follow the strong declension in the plural in modifying the vowel, and taking n in the dative—die Mutter (mother), die Mütter, and die Tochter (daughter), die Töchter.

(4) Nouns in niß take nisse, *e.g.* die Kenntniß (knowledge), die Kenntnisse.

(5) The following monosyllabic nouns make the plural in e, and modify the stem vowel in the plural:—

die Axt,	the axe.	die Luft,	the air.
die Angst,	the fear.	die Lust,	the pleasure.
die Bank,	the bench.	die Macht,	the power.
die Braut,	the bride.	die Magd,	the maid.
die Frucht,	the fruit.	die Maus,	the mouse.
die Gans,	the goose.	die Nacht,	the night.
die Hand,	the hand.	die Noth,	the need.
die Kraft.	the strength.	die Sau,	the sow.
die Kunst,	the art.	die Stadt,	the town.
die Kuh,	the cow.	die Wurst,	the sausage.

(Plural die Aexte, Aengste, &c.)

2. Of nouns masculine declined in the weak form the characteristic is the addition of n (or en) to all the cases except the nominative singular, *e.g.*—

	SINGULAR.		PLURAL.
N.	der Löwe,	the lion,	die Löwen.
G.	des Löwen,		der Löwen.
D.	dem Löwen,		den Löwen.
A.	den Löwen,		die Löwen.

The masculine nouns of this declension may be classified thus:—

(1) Nouns terminating in e designating living creatures, *e.g.* der Bote, the messenger; der Knabe, the boy; der Löwe, the lion; der Hase, the hare; also the names of nationalities ending in e, and some ending in er and ar, *e.g.* der Britte, the Briton; der Preuße, the Prussian; der Däne, the Dane; der Baier, the Bavarian; der Ungar, the Hungarian.

(2) The following nouns, which formerly ended in e, and are even now found so ending:—

SINGULAR.		PLURAL.
der Bär,	the bear,	die Bären.
der Christ,	the Christian,	die Christen.
der Fink,	the finch,	die Finken.
der Fürst,	the prince,	die Fürsten.
der Geck,	the fop,	die Gecken.
der Held,	the hero,	die Helden.
der Herr,	the master,	die Herren.
der Hirt,	the herdsman,	die Hirten.
der Mensch,	the man,	die Menschen.
der Narr,	the fool,	die Narren.
der Nerv,	the nerve,	die Nerven.
der Ochs,	the ox,	die Ochsen.
der Prinz,	the prince,	die Prinzen.
der Thor,	the fool,	die Thoren.

And the compounds—

der Hagestolz,	the old bachelor,	die Hagestolzen.
der Vorfahr,	the ancestor,	die Vorfahren.

These are declined—

	SINGULAR.		PLURAL.
N.	der Graf,	the count,	die Grafen.
G.	des Grafen,		der Grafen.
D.	dem Grafen,		den Grafen.
A.	den Grafen,		die Grafen.

(3) A large number of nouns having the following (chiefly foreign or classical) terminations—viz. and, ant, arch, at; ect, ent, et or est, ett, eut; gog, graph; ik, ist, it; lith, log; nom; ont, or, ost; soph; und, urg, ut, &c.

der Adjutant,	the adjutant.	der Philosoph,	the philosopher.
der Astronom,	the astronomer.	der Soldat,	the soldier.
der Jesuit,	the jesuit.	der Student,	the student.
der Katholik,	the catholic.	der Theolog,	the theologian.

THIRD DECLENSION.

III. To the third or MIXED DECLENSION belong such nouns as are declined in the singular like the first declension, and like the second in the plural, *e.g.*:—

der Aspect,	the aspect.	der Schmerz,	the pain.
der Diamant,	the diamond.	der See,	the lake.
das Ende,	the end.	der Sporn,	the spur.
das Insect,	the insect.	der Staat,	the state.
das Leid,	the sorrow.	der Strahl,	the ray.
der Mast,	the mast.	der Thron,	the throne.
das Ohr,	the ear.	der Unterthan,	the subject.

(Genitive Aspects, Diamants, Endes, &c.; plural Aspecten, Diamanten, Enden, &c.)

These include:—

(1) Masculine derivatives ending in or short, *e.g*, Doktor, Professor, &c. In these the accent is put, in the plural cases, on the syllable or, *e.g.* dok-tōr-en.

(2) Some derivatives, from foreign and classical sources, ending in um and in a, *e.g.*—

	GENITIVE.	PLURAL.
Dogma,	Dogmas,	Dogmen.
Gymnasium,	Gymnasiums,	Gymnasien.
Studium,	Studiums,	Studien.

Klima makes Klimate.

(3) Some neuter nouns which add in the plural ien, *e.g.*—

das Capital,	the capital.	das Material,	the material.
das Fossil,	the fossil.	das Mineral,	the mineral.
das Prinzip,	the principles.		

(4) A number of other foreign or classical words, *e.g.*—

der Augur,	the augur.	der Juwel,	the jewel.
der Consul,	the consul.	der Muskel,	the muscle.
der Pantoffel,	the slipper.		

Genius, genius, and Heros, hero, are invariable in the singular, and in the plural make Genien and Heroen.

DECLENSION OF PROPER NOUNS.

Such proper nouns as are never used without an article, as (1) the names of rivers, seas, lakes, mountains, and forests, and (2) the names of the masculine or feminine gender, follow the rules given for the declension of common nouns; but those proper nouns which are used without an article—names of persons, places, and neuter names of countries—observe the following rules:—

(1) They generally take in the genitive the termination s; as Friedrich, Friedrichs; Elisabeth, Elisabeths; Berlin, Berlins: thus—Nom. Karl (Charles), gen. Karls, dat. Karl, acc. Karl.

(2) Names of male persons ending in a sibilant (s, ß, x, sch, z) also take ens in the genitive and sometimes en in the dative; as—Nom. Max (Max), gen. Maxens, dat. Maxen, acc. Max.

(3) Foreign names ending in a sibilant, especially such as have an unaccented termination, are not declined, and the definite article is used to indicate the case; for instance, das

Heer des Xerxes, the army of Xerxes; das Schwert der Themis, the sword of Themis. The same method is sometimes employed in the case of names which can be inflected in the genitive, *e.g.* die Briefe des Cicero (or Ciceros Briefe), the epistles of Cicero.

(4) Christian names, when placed before family names, are not declined; as Ludwig Uhlands Balladen, Louis Uhland's ballads.

(5) Names of females ending in e follow the weak declension, but take in the genitive ens; as—Nom. Karoline (Caroline), gen. Karolinens, dat. Karolinen, acc. Karoline.

EXERCISE.

Write out the genitive singular and dative plural of the following nouns, and place before each the proper gender and case of the definite article:—

FIRST DECLENSION.

Ordinary—Rest, Holz, Arzt, Korb, Brod, Tag, Zahn (tooth).
Contracted—Vogel, Lehrer (teacher), Tropfen (drop), Mädchen, Name, Herz, Buchstabe, Glaube.
Extended—Reichthum (riches), Gott, Mann, Wald, Buch, Land.

SECOND DECLENSION.

Tante (aunt), Kirche (church), Göttin, Mütter, Besorgniss, Hand, Knabe, Rabe (raven), Däne, Ungar, Fürst, Herr, Soldat.

THIRD DECLENSION.

Ende, Leid, See, Doktor, Studium, Mineral, Jewel, Unterthan.

PROPER NOUNS.

Heinrich, Wilhelm, London, Fritz, Hercules, Eleonore, Louise.

After writing the above out (of course in English characters) refer to the previous lesson to test their accuracy. The meaning and gender of all words given as examples in these lessons should be carefully learned, so that the student may gradually acquire a large German vocabulary: in learning these words always learn along with each the nominative case of the definite article (*e.g.* der Wald, die Hand, das Kind), and this will be of great assistance in remembering the genders.

ENGLISH GRAMMAR AND COMPOSITION.—CHAPTER II.

ETYMOLOGY AND CLASSIFICATION OF NOUNS—NUMBER, GENDER, AND CASE.

NOUNS are the names (Lat. *nomen*, a name) of the subjects of discourse or the objects of the understanding.

Nouns, as names, are either (1) proper or (2) common.

The term *proper* is derived from Lat. *proprius*—belonging to one's self—as a separate and distinct individual, and not as a member of a whole class.

Common is a form of Lat. *communis*, a compound of *com*, together, and *mœnia*, walls, dwelling within the same walls, and so forming a community, having not perhaps all, but many things in common.

A *proper* noun is a mere designation meaningless in itself, except as being a mark by which a single individual is or may be known or registered in the mind, as Andrew, Milton, Thames, Chimborazo, &c. On this account it is called a proper name, *i.e.* a name appropriated to—and so made, in a sense, the property of—one particular person, place, or object. Though each is strictly applicable to one special individual, the necessities of speech have originated a usage which admits of our employing a plural form of some proper names—*e.g.* the Stephensons, father and son; the Thomsons, when spoken of as a family; and the Janes, to indicate several persons bearing that same Christian name. It happens also that when particular persons have acquired a high reputation for any quality, we sometimes use their name as a suggestive type or representative of a class. Thus we may speak of—a Peter in energy; a Paul in faith; some mute inglorious Milton; the Shakspeare of divines; the Burns of France. With a similar latitude of expression we occasionally use proper names with an ellipsis (or omission of words readily understood); as, "This is an Apollo" for "this is a statue of Apollo;" "this is a Rembrandt," omitting the words "picture by"; "he possesses a Stradivarius," meaning a violin made by the great Cremona artist in such instruments. In all cases a noun of this sort employed to signify, denote, recall, or register in the memory one single special individual, is a proper noun. From its very nature a proper noun cannot indicate plurality, and whenever it does so it becomes a common noun, and may be described as a proper noun used as a common one; as, Britain has never reared a Goethe, *i.e.* a person resembling Goethe by uniting in himself, in a pre-eminent degree, the qualities of that distinguished German poet, dramatist, novelist, philosopher, statesman, and conversationist; He is a Cicero in his club; There goes the Demosthenes of the party; Where are the Homers of the Crimean War? England's eight Henries; Thackeray lectured on the four Georges.

Common nouns may also be brought into such specific particularity of meaning as to become in fact and usage proper nouns, *e.g.* our Father, the Queen, the Swan of Avon, the Bard of Twickenham, the Poet of the Seasons, Scotia's Ploughman Poet, the voice of Nature; "O Grave, where is thy victory? O Death, where is thy sting?"

Common nouns are names by which several individual things, owing to their producing within us a mental feeling of their similarity in many respects, are marked in our minds, so that the one name is applicable to each particular individual of the class thus formed in thought, and is thus common to them all. Such names are river, city, man, ship, flower, book, quadruped, horse, dog, &c.

Common nouns may be arranged in almost any number of classes, according to their meaning or derivation, and grammarians are by no means agreed as to the extent to which it is advisable to subdivide them. Below we give three examples of classification, of which we will adopt the third.

I. Into three divisions, as (1) natural, as tree, field, sky; (2) artificial—chair, cloak, farm; (3) abstract—fancy, favour, goodness.

II. Into three classes—(1) substantive nouns or names of material or immaterial substances not expressive of collections of individual things, as air, water, iron, wind; (2) attributive nouns or names of properties, qualities, actions, influences, &c., assigned by us to things, but regarded as detached and existing apart from substantive things, as produce, power, folly, weakness, weeping, founding; (3) universal or generic nouns, those which are the names of classes of persons, things having substantive or attributive existence, as animal, tree, mansion.

III. Into five collections, as (1) real, as ocean, beast, ham; (2) ideal, as form, size, hope; (3) collective, as herd, flock, lot; (4) verbal, as living, laughing, to labour, to praise; (5) abstract, as glory, honour, patriotism. As this classification seems to have some advantages in clearness and definiteness, we adopt it here, and shall proceed to explain more precisely what these classes severally imply and include; and we may thereafter be enabled to propose a more distinct classification of nouns proper and common, which may dwell in the memory or may be readily referred to when requisite.

Real nouns are the names of such things as impress the senses—things to which we attribute reality, as man, sun, mill, car, farm.

Ideal nouns are those names which we use to indicate conceptions formed in the mind, having no known outward reality corresponding to them, *e.g.* fairy, ghost, gnome.

Collective nouns are names of classes of persons or things spoken of as a whole, as clergy, laity, jury, bench, parliament, board, commission. They are singular in form though referring to many individuals, and therefore they can often take a plural form, *e.g.* crowd*s*, multitude*s*, regiment*s*, church*es*.

Collective nouns are often formed by the following affixes—viz. *y, cy, ry, ty, ity, ism, age, hood, dom, ric, ship, ture, wic, ow, iad, ade*, as covey, orphancy, yeomanry, party, authority, whiggism, coinage, childhood, kingdom, bishopric, fellowship, legislature, bailiwic, shadow, Rolliad, decade, &c. To these might be added *al, ance, der, ter, ment, ure, t, th*, as in trial, insurance, remainder, laughter, endowment, departure, weft, growth, &c.

Verbal nouns are names of actions referred to as conceptions, *e.g.* to live, to speak, reading, veering, betrothed, &c.

Abstract nouns are names of qualities, attributes, and ideas considered as existences in themselves, and apart from the persons and things which possess them; as whiteness, cruelty, flight, wisdom, vanity, pride, &c.

The terminations which are generally used to form abstract nouns are *y*, *ey*, *ry*, *ity*, *ty*, *th*, *age*, *hood*, *dom*, *ship*, *ness*, &c., as honesty, survey, bravery, equality, verity, truth, bondage, likelihood, freedom, hardship, sweetness.

Nouns denoting *real*, and not merely *ideal*, things are sometimes distinguished from abstract nouns by being designated *concrete*, *i.e.* material.

The determination of systems of classification is in reality rather a logical than a grammatical duty; but as it is helpful in enabling us to use words more accurately, to know not only the *form* they take, but the *thought* they imply, it will be useful to have before the mind's eye some form of classification of the nouns in our language to which we can refer on any occasion of difficulty. We therefore lay before the student the following formal

CLASSIFIED TABLE OF NOUNS.

I. Proper,	Names of special individuals,		Milton, Homer.
	Names in a transition state,		"Some Cromwell guiltless of his country's blood."
II. Common,	1. General,	1. Real or sensible,	book, star.
		2. Ideal or mental,	hero, engineer.
		3. In transition,	the Empress of India.
	2. Collections or groups,		gang, navy.
	3. Materials or substances (real),		milk, gas, gold.
	4. Quantities and numbers (ideal),		yard, ton, hundred.
	5. Agents (real or ideal),		worker, inventor.
III. Verbal,	1. Participial,		loving, betrothed.
	2. Infinitive,		to sleep, to err.
IV. Abstract,	1. Names of states,		life, death, fortune.
	2. " of acts,		thinking, speaking,
	3. " of qualities,		greatness, weakness.
	4. " of degree,		excess, defect.

It will be found a useful exercise to rule a sheet of paper, in the form shown below, and fill up each of the columns with examples.

NOUNS.

(1) PROPER.		(2) COMMON.				
(1) Special.	(2) Transitional.	(1) Real.	(2) Ideal.	(3) Abstract.		Collective.
				(1) Adjective.	(2) Verbal.	

NUMBER.

Our ideas of things impress us with the feeling of singleness or plurality. Thus the notion of number originates. We often feel it necessary to indicate whether we are speaking of one or more than one. To do so we most frequently vary the form of the words we use. The form of the noun we employ when we speak of one thing only is called *singular*, as ship, house, &c., and that which denotes more than one *plural*, as ships, houses, &c. This change is called an inflexion.

The singular is regarded as the original form of the noun, and the plural is said to be formed from it by making certain changes in or upon the singular. This is done in several ways, although a general principle predominates in our inflexions for number. Many of those instances which are classed together by grammarians as exceptions are in reality the result of special influences, euphonic and orthographic, operating upon the pronunciation and spelling of words, and imparting to them an apparent rather than a real departure from agreement with the general rule, which is as follows:—

The plural is formed from the singular, in general, by adding *s*. This rule includes especially the following cases, (1) nouns ending in silent *e* if preceded by a consonant not having the sound of *s*, as babe*s*, blade*s*, scythe*s*, joke*s*, scale*s*, name*s*, rope*s*, share*s*, slate*s*, dove*s*; (2) nouns ending in one vowel preceded by another, as guinea*s*, bee*s*, lie*s*, hernia*s*, foe*s*, cue*s*, eye*s*, cuckoo*s*, embryo*s*, folio*s*, straw*s*, view*s*, day*s*, key*s*, money*s*, viceroy*s*, guy*s*, quay*s*; (3) nouns ending in any consonant, sharp or flat, other than *s*, but that can readily coalesce with it, as web*s*, arc*s*, bed*s*, skiff*s*, flag*s*, path*s*, rock*s*, hill*s*, ham*s*, fan*s*, prop*s*, burr*s*, hat*s*, the plural *s* being pronounced sharp or flat in sympathy with the kind of consonant it follows; (4) nouns ending in *i*, in *u*, and in *e* sounded, also add *s* only, as alkali*s*, gnu*s*, epitome*s*. But the following special sub-rules require particular attention, viz.:—

I. Singular nouns ending in (1) *ch* (sounding *tsh*), *sh*, *s*, *ss*, *x*, and *z* add the syllable *es* to form their plural, as torch-*es*, blemish-*es*, gas-*es*, hiss-*es*, hoax-*es*, topaz-*es*; and in (2) *ce*, *ge*, *che*, *se*, *xe*, and *ze* add *s* only; but increase a syllable, as face*s*, page*s*, niche*s*, praise*s*, axe*s*, maze*s*.

II. Singulars in *y*, preceded by a consonant, change *y* into *i*, and add *es*, as ally, allies; city, cities; colony, colonies; eddy, eddies; soliloquy, soliloquies.

III. Nouns ending in (1) *o* short add *es*, as cargo*es*, echo*es*, hero*es*, negro*es*, potato*es*; (2) in *o* long add *s* only, as canto*s*, folio*s*, grotto*s*, junto*s*, nuncio*s*, punctilio*s*, quarto*s*, solo*s*.

IV. Of nouns ending in *f* or *fe* the following (1) change *f* into *v* and add *es*, namely, corf, corves; leaf, leaves; sheaf, sheaves; beef, beeves; neif, neives; thief, thieves; knife, knives; life, lives; wife, wives; calf, calves; half, halves; helf, helves; elf, elves; self, selves; shelf, shelves; and wolf, wolves; (2) those add *s* only—chief*s*, handkerchief*s*, mischief*s*, relief*s*, bas-relief*s*, brief*s*, fief*s*, grief*s*, clef*s*, coif*s*, oaf*s*, waif*s*, gulf*s*, reef*s*, hoof*s*, roof*s*, proof*s*, reproof*s*, woof*s*, turf*s*, serf*s*, surf*s*, scurf*s*, scarf*s*, dwarf*s*, wharf*s*, fife*s*, strife*s*, safe*s*.

V. The following nouns form their plural, after the old fashion of our language, by making a change in the vowel, viz., man, men; woman, women; foot, feet; goose, geese; tooth, teeth; mouse, mice; louse, lice.

VI. In these others we have a remnant left of another old-fashioned plural ending in *en*, as ox, oxen; cow (formerly *cu*, plural *cy* or *kye*), kine; sow, swine; child, children; brother, brothers (by blood), brethren (of an order, community, sect, &c.)

VII. Some words which were uninflected in Old English are used unchanged in singular and plural; as heathen, deer, sheep, neat (including steer, heifer, and calf), grouse, teal, salmon, trout, cod, mackerel, perch, tench, herring, &c.

VIII. Other parts of speech when used as nouns, if requiring to form a plural, do so in accordance with the prevalent usage; as six*es* and seven*s*, two*s* and three*s*, whereby*s*, therewith*s*, no*es*, nay*s*, whereof*s*, in*s* and out*s*, and*s* and or*s*, forsooth*s* and yes*es*, saying*s* and doing*s*, why*s*, wherefore*s*, and because*s*.

IX. Some nouns have no plurals:—1. Proper names, except when used as common nouns, as the Howards, the Tells. 2. Nouns denoting things that are usually weighed or measured, except when *kind*, not quantity, is mentioned, as tea, coffee, pitch, wax, oil, &c. 3. Names of metals, earths, grains, herbs, virtues, vices, abstract nouns, &c., except when different kinds are meant, as gold, clay, wheat, pulse, mint, pride, sloth, poetry, &c.

X. Abstract and collective nouns when used as common nouns take a plural form, *e.g.* virtues, graces, meats, drinks, oils, &c.

XI. Some nouns though used as singular have the plural form, and others have only the plural form though they may be used either with singular or plural verbs, as—

Aborigines.	Bellows.	Customs.	Hatches.	Literati.
Alms.	Betters.	Dogsears.	Hose.	Lungs.
Amends.	Billiards.	Drawers.	Hustings.	Mallows.
Annals.	Bitters.	Dregs.	Hysterics.	Manacles.
Antipodes.	Bowels.	Embers.	Ides.	Manners.
Archives.	Breeches.	Entrails.	Illuminati.	Matins.
Arms.	Cates.	Gallows.	Kalends.	Means.
Ashes.	Cattle.	Greaves.	Kinsfolk.	Measles.
Assizes.	Compasses.	Goods.	Lees.	Minutiæ.
Assets.	Clothes.	Gyves.	Letters.	Morals.

Nippers.	Pains.	Seeds.	Stays.	Trousers.
News.	Pantaloons.	Sessions.	Stilts.	Umbles.
Nones.	Pinchers.	Shambles.	Sweepstakes.	Vespers.
Nuptials.	Pliers.	Shackles.	Teens.	Victuals.
Oats.	Premises.	Shears.	Thanks.	Vitals.
Obsequies.	Remains.	Snuffers.	Tidings.	Wages.
Odds.	Riches.	Spectacles.	Tongs.	Withers.
Orgies.	Scissors.	Stairs.	Trappings.	Yellows.

XII. Names of sciences ending in *ics* are used with a singular or a plural verb according to sense or choice, as acoustics, optics, mathematics, ethics, &c.

XIII. A few nouns have double plurals; each plural, however, conveys a different meaning, as—

Appendix.	Appendixes—additions (of matter). Appendices—additions (of exposition).
Brother.	Brethren—members of the same society or church. Brothers—sons of the same parents.
Die.	Dies—stamps for coining. Dice—small cube-formed articles used in gaming.
Fish.	Fishes—when number is spoken of. Fish—when quantity or species is considered.
Genius.	Geniuses—men of great mental ability. Genii—imaginary beings.
Index.	Indexes—tables of contents. Indices—algebraic exponents.
Pea.	Peas—number. Pease—quantity.
Penny.	Pennies—single coins. Pence—in computation

XIV. Several Latin and Greek words adopted from the classics retain their original plurals, as do also some others adopted from Hebrew, French, and Italian. The following are the most commonly used of these:—

LATIN.

Singular. *um.*	*Plural.* *a.*
Addend-um,	a.
Animalcul-um,	a.
Arcan-um,	a.
Credend-um,	a.
Dat-um,	a.
Dict-um,	a.
Desiderat-um,	a.
Errat-um,	a.
Encomi-um,	a.
Effluvi-um,	a.
Gymnasi-um,	a.
Medi-um,	a.
Millenni-um,	a.
Memorand-um,	a.
Moment-um,	a.
Postulat-um,	a.
Strat-um,	a.

Singular. *ix* or *ex.*	*Plural.* *ces.*
Ap-ex,	ices.
Append-ix,	ices.
Ind-ex,	ices.
Rad-ix,	ices.
Vert-ex,	ices.
Vort-ex.	ices.

Singular. *us.*	*Plural.* *i*, *era*, or *ora*.
Alumn-us,	i.
Calcul-us,	i.
Corp-us,	ora.
Echin-us,	i.
Foc-us,	i.
Fung-us,	i.
Geni-us,	i.
Gen-us,	era.
Ign*is*-fatu-us,*es*,	i.
Mag-us,	i.
Myth-us,	i.
Polyp-us,	i.
Radi-us,	i.
Ranuncul-us,	i.
Sarcophag-us,	i.
Stimul-us,	i.
Tumul-us,	i.

Singular. *a.*	*Plural.* *æ.*
Formul-a,	æ.
Lamin-a,	æ.
Larv-a,	æ.
Macul-a,	æ.
Minuti-a,	æ.
Nebul-a,	æ.
Scori-a,	æ.
Siliqu-a,	æ.

Sing. en.	*Plur. ina.*
Stam-en.	Stam-ina.

GREEK.

Singular. *is.*	*Plural.* *es* or *ides.*
Amanuens-is,	es.
Analys-is,	es.
Aph-is,	ides.
Aps-is,	ides.
Ax-is,	es.
Bas-is,	es.
Calx,	ces.
Cris-is,	es.
Diæres-is,	es.
Ellips-is,	es.
Emphas-is,	es.
Hypothes-is,	es.
Metamorphos-is,	es.
Oäs-is,	es.
Parenthes-is,	es.
Phas-is,	es.
Synops-is,	es.
Thes-is,	es.

Singular. *on* and *a.*	*Plural.* *a* and *ata.*
Automat-on,	a.
Apheli-on,	a.
Criteri-on,	a.
Dogm-a,	ata.
Miasm-a,	ata.
Phenomen-on,	a.
Stigm-a,	ata.

FRENCH.

Beau,	Beaux.
Belle-lettre,	Belles-lettres.
Billet-doux,	Billets-doux.
Madame,	Mesdames.
Monsieur,	Messieurs.

ITALIAN.

Bandit, Banditto,	Banditti.
Cognoscente,	Cognoscenti.
Conversazione,	Conversazioni.
Dilettante,	Dilettanti.
Virtuoso,	Virtuosi.

HEBREW.

Cherub, Cherubim. Seraph, Seraphim. Teraph, Teraphim.

A considerable number of classical and foreign words have, however, been naturalized, as it were, and now, unless under very special circumstances, form the plurals in the English way; as asylum*s*, athenæum*s*, choruse*s*, circuse*s*, compendium*s*, cranium*s*, criterion*s*, decorum*s*, dervise*s*, emporium*s*, encomium*s*, forum*s*, lustrum*s*, mausoleum*s*, museum*s*, nostrum*s*, pendulum*s*, prospectuse*s*, rebuse*s*, rostrum*s*, surpluse*s*, trellise*s*, vacuum*s*.

As a general rule, whatever idea requires to be most vividly and definitely expressed as to unity or plurality overrides all mere pedantic collocations, and not only shapes the words to indicate the thought, but constructs the syntax to show it. Hence we say—The council meets at one. The jury is deliberating. Society is at one in this matter. The people is enthusiastic. But we may also require to use—The council were at odds on the question. The jury are disconcerted. Society were dispersed after the season. The people are in an uproar.

When a name and a title are to be used together in a plural sense, the question whether (1) the name, (2) the title, or (3) both should be put in the plural form is to be determined by the intention of the speaker. We never hesitate to say—The Messrs. Smith, The knights banneret; and we can use, The two Doctors Craig, or, The three Doctors Simpson; but when we require to address two ladies named Bell, and both Misses, we are puzzled to decide whether we shall say or write—The Misses Bell, the Miss Bells, or the Misses Bells. It is probable that if there are male members of the family Bell, and we intend only to address or speak of the young ladies, the Misses Bell would be correct; if there were married members of the family of Bell, and we wished to address or refer to the unmarried members of the family, Miss would be a title of discrimination, and therefore the Miss Bells would be correct; but if there were no other lady members of a family of Bells except those who were Misses, the phrase to be employed would be a compound, one in which the two words would be put in apposition, as the Misses Bells. In the one case we indicate *who* they are, in the other *what* they are, with special distinctness.

GENDER.

Sex is a distinction established by nature between living beings of the same species. As a fact it affects thought; and words, as the representatives of thought, are also influenced by it. Men have in all ages been impressed by that peculiar idea of similarity with difference which experience supplies, as manifested in the existence of male and female. They have been in the habit of recognizing this distinction in life and speech. The incorporation of this notion with the words they employed has led them to indicate difference of sex with more or less particularity, by inflexion or otherwise, in almost every language. The classification of words arising from this arrangement is called *gender* (Lat. *genus*, kind or class). It must, of course, in the early stages of language, have had its first suggestion in the facts of human life, and of the life of those living creatures with which man was brought more immediately into contact, either as domesticated animals or as wild beasts incapable of being reduced to servitude and dangerous as foes. Of by far the larger part of the animal creation, man can acquire readily no knowledge of the distinction of sex, and such knowledge, even if gained, would not be of any great use in the current speech of common life. In some languages the idea of gender has been interwoven into their entire texture, and every word is considered as masculine or feminine even though they are inanimate, and therefore sexless; in others some endeavours have been made to conform language to nature, and to make those names which denote male beings *masculine* and female beings *feminine*, while things without life are regarded as neither, and are on that account designated *neuter* (Lat., neither). This has not, however, been well done, and gender has become a difficulty in the study of many languagss. In English the names of creatures of the male sex are masculine, as boy, man, king, &c.; of the female, feminine, as girl, woman, queen, &c.; and all other things are neuter. But in practice modern English speech has been almost entirely divested of indications of sex. Unless where it is absolutely necessary for the purpose of the speaker or hearer or very requisite for clearness of meaning, the whole task of indicating gender is laid upon the pronoun (as we shall see hereafter), and the noun most usually bears

none of the burden. We speak of parent, cousin, friend, neighbour, person, partner, monarch, sovereign, citizen, speaker, writer, teacher, tenant, servant, &c., without indicating by any change in these and similar nouns the sex of those to whom we are referring. It has been usual among grammarians to designate such nouns as of common gender; it is probably more accordant with the facts of life to use with regard to them the phrase "of either gender," a logical opposite to neuter, *i.e.* of neither gender, while we retain the masculine and the feminine gender, as the signs of the twofold correlative distinction of sex.

The practice in regard to the classification of nouns by gender may be represented by the following statements, viz.:—

I. Nouns "of either gender" or "of neither gender" take no change, *e.g.* child, worshipper, guardian, slave, maker, arm, road, house, field, &c.

II. When there is need, from the constant requirements of society, to indicate difference of gender we use different words for the differing genders. Of these the following are in most common use:—

Masculine.	Feminine.	Masculine.	Feminine.
Man,	Woman.	Goodman,	Goody.
Lad,	Lass.	Grandfather,	Grandmother.
Beau,	Belle.	Host,	Hostess.
Bridegroom,	Bride.	Knight,	Dame.
Bridesman,	Bridesmaid.	Nephew,	Niece.
Husband,	Wife.	Widower,	Widow.
Father,	Mother.	Sir (Sire),	Madam.
Papa,	Mamma.	Master,	Mistress.
Boy,	Girl.	King,	Queen.
Son,	Daughter.	Earl,	Countess.
Brother,	Sister.	Duke,	Duchess.
Bachelor,	Maid. / Spinster.	Friar, Monk,	Nun.
Swain,	Nymph.	Wizard,	Witch.
Youth,	Damsel.	Sloven,	Slut.
Uncle,	Aunt.	Lord, Gentleman,	Lady.
Gaffer,	Gammer.		

Also all components of these words, as barman, barmaid; foster-father, foster-mother; landlord, landlady.

Masculine.	Feminine.	Masculine.	Feminine.
Hart,	Roe.	Hound, Dog,	Bitch.
Buck,	Doe.		
Stag,	Hind.	Boar, Hog,	Sow, or Swine.
Horse, Stallion,	Mare.	Fox,	Vixen.
Colt,	Filly.	Drake,	Duck.
Sire,	Dam.	Mallard,	Wild-duck.
Bull, Ox,	Cow.	Cock,	Hen.
		Gander,	Goose.
Bullock, Steer,	Heifer.	Ruff,	Rieve.
		Milter,	Spawner.
Ram, Wether,	Ewe.	Drone,	Bee.

III. When necessity arises we indicate the feminine by adding the termination *ess* to the masculine noun (sometimes slightly changed, sometimes unaltered)—

Masculine.	Feminine.	Masculine.	Feminine.
Abbott,	Abbess.	Editor,	Editress.
Actor,	Actress.	Elector,	Electress.
Adulterer,	Adulteress.	Emperor,	Empress.
Ambassador,	Ambassadress.	Enchanter,	Enchantress.
Adventurer,	Adventuress.	Exactor,	Exactress.
Ancestor,	Ancestress.	Founder,	Foundress.
Arbiter,	Arbitress.	Giant,	Giantess.
Auditor,	Auditress.	Governor,	Governess.
Author,	Authoress.	Heir,	Heiress.
Baron,	Baroness.	Host,	Hostess.
Benefactor,	Benefactress.	Huckster,	Huckstress.
Canon,	Canoness.	Hunter,	Huntress.
Caterer,	Cateress.	Idolater,	Idolatress.
Chanter,	Chantress.	Instructor,	Instructress.
Citizen,	Citizeness.	Inspector,	Inspectress.
Coheir,	Coheiress.	Jew,	Jewess.
Conductor,	Conductress.	Leopard,	Leopardess.
Count,	Countess.	Lion,	Lioness.
Dauphin,	Dauphiness.	Marquis, Marquess,	Marquise, or Marchioness.
Deacon,	Deaconess.		
Director,	Directress.	Master,	Mistress.
Mayor,	Mayoress.	Sculptor,	Sculptress.
Monitor,	Monitress.	Seamster,	Seamstress.
Murderer,	Murderess.	Shepherd,	Shepherdess.
Negro,	Negress.	Solicitor,	Solicitress.
Ogre,	Ogress.	Songster,	Songstress.
Patron,	Patroness.	Sorcerer,	Sorceress.
Peer,	Peeress.	Spinner,	Spinstress.
Poet,	Poetess.	Steward,	Stewardess.
Porter,	Portress.	Tailor,	Tailoress.
Priest,	Priestess.	Teamster,	Teamstress.
Preceptor,	Preceptress.	Tiger,	Tigress.
Prince,	Princess.	Traitor,	Traitress.
Prior,	Prioress.	Tyrant,	Tyranness.
Proprietor,	Proprietress.	Victor,	Victress.
Prophet,	Prophetess.	Viscount,	Viscountess.
Protector,	Protectress.	Votary,	Votaress.
Python,	Pythoness.	Waiter,	Waitress.

IV. We adopt some words (1) from the Latin with the masculine ending in *tor*, the feminine in *trix*—Administrator, administratix; coadjutor, coadjutrix; executor, executrix; testator, testatrix, &c.; (2) from other languages having a feminine ending in *ine*, *ina*—Czar, czarina; hero, heroine; landgrave, landgravine; margrave, margravine, &c.; or, making a feminine in *a*—Don, donna; infante, infanta; amoroso, amorosa; signore, signora or signorina; sultan, sultana, &c.

V. We form compound nouns in part of which we indicate the gender, as man-servant, maid-servant; schoolmaster, schoolmistress; men-singers, women-singers; sakeret, saker-hawk; moor-cock, moor-hen; cock-sparrow, hen-sparrow; billy-goat, nanny-goat; he-goat, she-goat; buck-rabbit, doe-rabbit; bull-calf, cow-calf; boar-pig, sow-pig; tom-cat, tabby-cat.

Some proper nouns take feminine forms derived from the masculine—

Masculine.	Feminine.	Masculine.	Feminine.
Alexander,	Alexandra.	John.	Joan.
Alfred,	Elfrida.	Julius,	Julia.
Charles,	Carolina.	Julian,	Juliana.
Clement,	Clementina.	Robert,	Robertina.
George,	Georgina.	Thomas,	Thomasina.
Harry,	Harriet.	William, Wilhelm,	Wilhelmina.
Henry,	Henrietta.		

Derivative words having the following terminations are usually masculine, viz. (1) *iff*, *ite*, *ary*, added to nouns, as plaintiff, Israelite, depositary; (2) *ar*, *ard*, *er*, *or*, *ant*, *ee*, *ist*, added to verbs, *e.g.* beggar, drunkard, doer, worker, sailor, accountant, trustee, &c.

The English language is peculiarly favourable to personification. Names of things that have no life, having in it no indication of gender, can be animated at once by endowing them immediately with the attributes of sex—provided that is done in agreement with their nature. This is not always easily and appropriately done; for there are no well-fixed rules of general application and universally accepted authority regarding the subject. The practice of the best writers is in this matter inconsistent with each other. Samuel Daniel, in his "Complaint of Rosamond," makes Jealousie daughter of Envy and Love (feminine), but Darwin, making the same passion masculine, says—

> "The demon Jealousy, with Gorgon frown,
> Blasts the sweet flowers of pleasure not his own;
> Rolls his wild eye, and thro' the shuddering grove
> Pursues the steps of unsuspecting love;
> Or drives o'er rattling plains his iron car,
> Flings his red torch and lights the flames of war."

David Booth, in his "Analytical Dictionary," has, after a special investigation of this subject, deduced from the practice of 150 authors the gender attributed by them to nearly 1500 common nouns. From a consideration of the imaginative gender which these authors and many others assign to objects in nature, works of art, and qualities of mind, we can gather up a few general guiding ideas on the use of gender as an element in personification, and so reflexly upon the principles which underly and regulate the ascription of gender to

inanimate objects and abstract ideas in such languages as Greek, Latin, German, and French.

I. Inanimate things to which the speaker is attached, and with which his interests are bound up, are generally referred to as if feminine. Thus, a sailor refers to his *ship*, the husbandman to his *plough*, the mower to his *scythe*, the forester to his *axe*, the gamekeeper to his *gun*, &c., as feminine, though, strangely enough, the spade and the prong of the day-labourer are spoken of as masculine.

II. Any inanimate object or abstract idea commending itself to the mind for grace, beauty, excellence, attractiveness, and worth, are regarded as feminine; while those that suggest power, courage, roughness, boisterousness, the capacity of giving pain or doing damage, are masculine. Hence the sun is masculine, the moon feminine; the sky, the earth, the sea, are feminine; winds, thunder, rocks, and mountains, are masculine; love, truth, mercy, faith, peace, and plenty, are feminine; cruelty, vengeance, tyranny, time, poverty, death, masculine.

III. A great many objects have a sort of traditionary gender appropriated to them from associations derived from our readings of the classics, or gathered from the impressions of tales told us in our infancy. Religion, poetry, imagination, and fable, concur in keeping alive in our minds the influences of personification, and in our practice we are guided pretty much by the usages of early thought and ancient literature. The poets yield us such personifications as the following, which may illustrate the foregoing remarks.

Masculine.	Feminine.	Masculine.	Feminine.
Agony.	Delight.	Lust.	Chastity.
Ambition.	Subordination.	Treachery.	Sincerity.
Austerity.	Kindness.	Pride.	Meekness.
Cruelty.	Goodnature.	Rusticity.	Elegance.
Darkness.	Light.	Want.	Abundance.
Frowardness.	Gentleness.	Vice.	Virtue.
Death.	Life.	Humility.	Vanity.
Haughtiness.	Bashfulness.	Winter.	Spring.
Intemperance.	Temperance.	Stubbornness.	Penitence.

But the unsettled state of this imaginary gender may be seen when we mention that Shakspeare and Daniel make ocean masculine, while Dryden makes it feminine; opinion is masculine in Shakspeare, feminine in Drayton; necessity is masculine in Shakspeare, feminine in Akenside; murder is masculine in Shakspeare, feminine in Campbell. Shakspeare and Milton agree in making error masculine, while Spenser makes it feminine; mirth is masculine in Chaucer, feminine in Spenser and Collins; Gower makes mercy masculine, Milton regards it as feminine; King James I. gives patience masculine attributes, his servant Shakspeare treats her as feminine. The idea which predominates in the imagination will regulate the personification, and will represent the noun as of that gender which is most appropriate to the purposes in view.

CASE.

Logically, *case* signifies the relation which nouns bear to each other and to other words; but etymologically it means the changes made in the form of nouns to indicate these relations. In modern English it means no more than the way in which a noun is used in connection with other words.

Nouns in sentences are either leaders or subordinates, *e.g.*—"Lord Bacon says, Knowledge is power." The leader of thought is Lord Bacon; the wise saying of Lord Bacon is subordinate to the verb, the object of the verb's influences; but in the proverb itself the relation of equality is asserted of "knowledge" and "power." In the sentence as it stands, "Lord Bacon" is the nominative to the verb "says," and "knowledge is power" is the objective to that verb; but in the proverb the separate words "knowledge" and "power" are each in the same case, and that is the nominative. In the sentences, John read the book, John gave the book to David, John took the book from David—"John" is the nominative of all three, "book" holds the subordinate position of being read, given, or taken, and "David" holds the subordinate relation of receiving it in the one case and of being deprived of it in the other. In the old languages, and in some living ones, these nouns would have their relations of leadership or subordination indicated by the form of the nouns, as nominative, accusative, dative, or ablative. But though, logically, English recognizes case as an element in syntax, and has had therefore to provide, in the pronouns, some indication of it, etymologically it makes no change in the form of its nouns to indicate any relation of things to each other, except one, and that is for the possessive case. That case indicates the source from which anything proceeds; and as that from which anything is received is generally the owner of it, either really or at least as far as we are concerned, this has come to be the prevailing idea, and it has given its name to this the only inflexional augment used in English to denote case.

There are logically, not etymologically, three cases—Nominative, Possessive, and Objective.

A noun is in the nominative when it is the subject of an affirmation, *i.e.* the name of what we speak about.

The possessive denotes (1) proceeding from or out of, and (2) possession.

The possessive is indicated by the addition of an apostrophe and *s* ('s) to the singular, and by the apostrophe (') alone in the plural, except when the plural does not end in *s*, in which case the plural follows the same rule as the singular. Or we may give the rule this fourfold form—(1) Singular nouns that end in *s*, *ce*, *ge*, or *x* add an apostrophe (') only, as Moses' death; (2) singular nouns that do not end in an *s*-sound add an apostrophe and *s* ('s), as Longfellow's "Hyperion;" (3) plural nouns ending in *s* add an apostrophe (') only, as Critics' approval; (4) plural nouns not ending in *s* add an apostrophe and *s* ('s), as Men's destinies.

The possessive is frequently formed by the use of *of* before the noun or pronoun, *e.g.* The crown of the king; A servant of the Lord; "Ay, and that tongue *of his* which bade the Romans mark him;" "These threats *of theirs* disturb me not a jot." These may be called (1) the apostrophic, and (2) prepositional possessives respectively.

A noun is in the objective when it is the name of the object upon which an action is performed, or in which the relation implied in a preposition is exhibited.

The nominative and objective of nouns are alike in form.

EXERCISES IN NUMBER, GENDER, AND CASE.

(1) Change the following apostrophic into prepositional possessives:—Shakspeare's works; Milton's writings; Stephenson's locomotives; the queen's commands; the country's prosperity; the children's welfare; the tree's root; my father's watch; Watt's engines; gentlemen's incomes; travellers' expenses; missionaries' adventures; bankers' investments; merchants' accounts; workmen's wages; ladies' ornaments; princes' vestures; artists' sketches.

(2) Change the following prepositional into apostrophic possessives:—The word of God; the writings of Lord Bacon; the treasury of the rich man; the mite of the widow; the novels of Thackeray; the pleasures of hope; the songs of Burns; the death of Socrates; the letters of Lord Byron; the Adonais of Shelley; the outcasts of society; the wit of Douglas Jerrold; the sarcasm of Dean Swift; the poetry of Schiller; the grief of a sister; the speech of a candidate; the roof of a church; the face of Othello; the woes of Dido; the brightness of Beatrice.

Make out a form such as is given below and fill up the columns with examples—

THE FORMATION OF THE PLURAL OF NOUNS, No. 1.

I. By adding *s*.	II. By adding *es*.	III. By changing *y* into *i* and adding *es*.	IV. Saxon Plurals.	V. Classical and Foreign.

THE FORMATION OF THE PLURAL OF NOUNS, No. 2.

I. Ending in *o*, adding *s*.	II. Ending in *o*, adding *es*.	III. Ending in *y*, adding *s*.	IV. Ending in *y*, adding *es*.	V. Ending in *f* or *fe*, adding *s*.	VI. Ending in *f* or *fe*, changing into *ves*.

THE GENDER OF NOUNS, No. 1.

I. Masculines.	II. Feminines.	III. Neuters.

THE GENDER OF NOUNS, No. 2.

I. Mas. & Fem. different words.		II. M. and F. by inflexion.		III. M. and F. by prefix.		IV. M. and F. by affix.	
M.	F.	M.	F.	M.	F.	M.	F.

THE CASES OF NOUNS.

I. PROPER.		II. COMMON.			
(1) Nominative and Objective.	(2) Possessive.	(1) Nominative and Objective. *Singular.*	(2) Possessive. *Singular.*	(3) Nominative and Objective. *Plural.*	(4) Possessive. *Plural.*

GEOLOGY.—CHAPTER II.

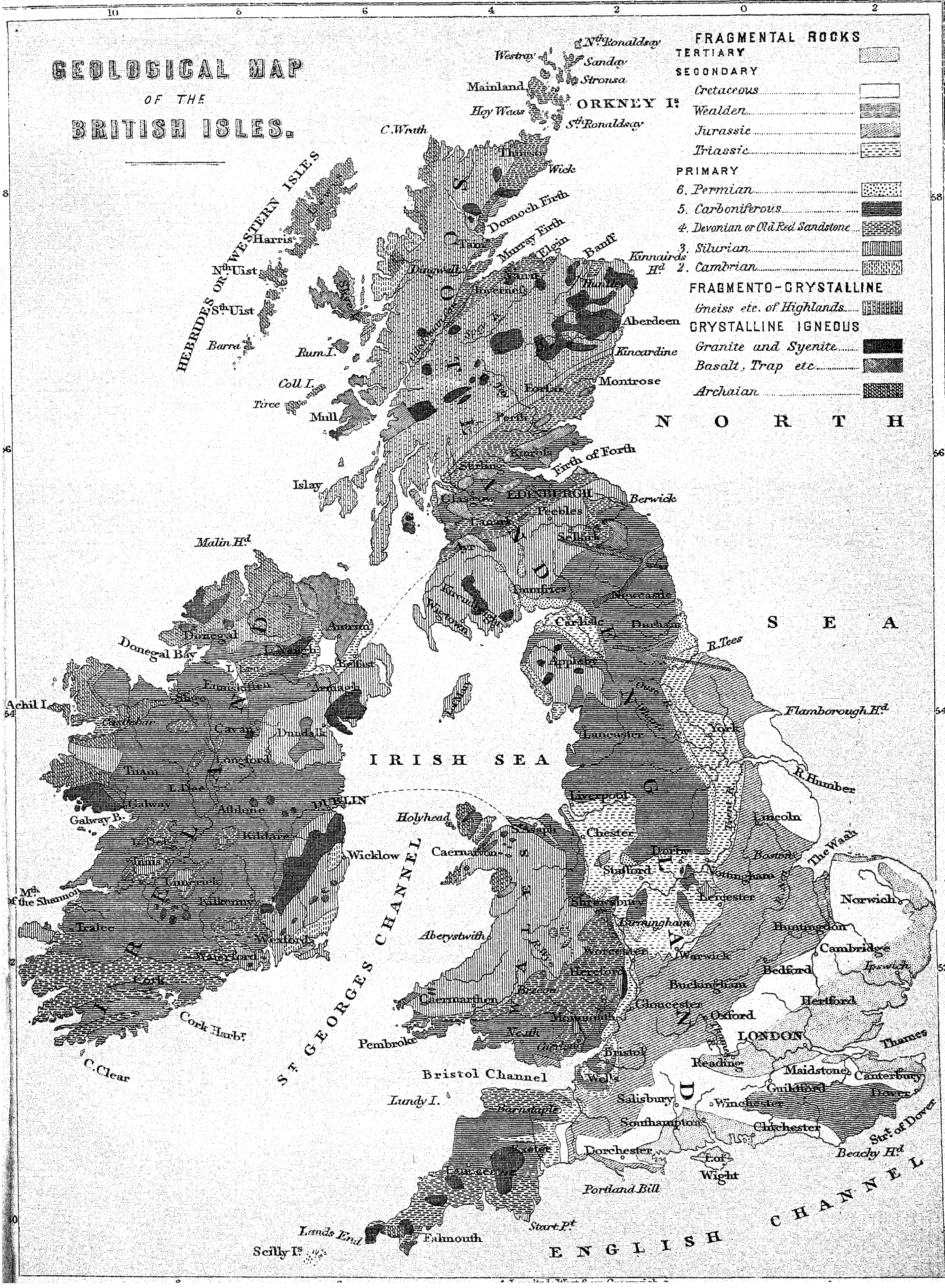
THE ORIGIN OF GEOLOGY AS A SCIENCE—THE ASPECTS AND FORCES OF NATURE—STRATIFICATION.

GEOLOGY is the youngest-born of the real sciences. The aim it has in view, the phenomena to be explained by it, the forms of experiment and reasoning best adapted to advance it, and the true conception of it as an inductive science, have only in recent times been so formulated as to constitute it a distinct field of research. In the earlier ages of history only a small portion of the surface of any country was explored, and the aspects of nature were known rather in their ordinary modes than in their singular diversities. Observation had little scope, the records made of what was noticed were scanty and unsystematic, and when any violent or unexpected change occurred in the course of the world's ongoings, it was looked on as a marvel and a mystery, rather than as a problem to be solved or a subject for inquiry as to its cause. Before natural philosophy, by its severe and rigorous scrutiny of powers and forces operating on the arrangement, collocation, and juxtaposition of bodies or particles of bodies in mass, or chemistry had subjected the changes, influences, and effects which are observable in the inner essential qualities of things to thorough investigation; before mechanical science had so perfected itself as to be capable of performing the singular feats of engineering now given it to do, and mathematics had acquired the wondrous calculus by which it estimates and weighs, measures and gauges forces and phenomena, the physical life of the globe, as it were, the real and potential activities of nature, in their occurrence and recurrence, could scarcely be brought under the inquisition of the philosopher as actual subjects of speculation and experiment. Of course there were, ever and anon, phenomenal marvels striking the mind and evoking thought, instances of which might be gleaned from ancient and mediæval writers. Earthquakes and volcanic eruptions, submersions of land, changes in sea-level, disruptions and divulsions of mainland, rock, or insular surface; the discovery of marine shells in inland valleys or mountain uplands, excited surprise, startled (and mostly always baffled) curiosity, and had note taken of it, but no conception of a systematic survey of the entire phenomena of the globe as a special planetary unit, and of all the physical agencies operating on and within it towards change—incidental, accidental, or recurrent—appears to have taken possession of the mind of ancient or of mediæval sages. No body of methodized information upon these points has come down to us, and but for some traditionary fragments of cosmogony derived from Chaldea, Phœnicia, Egypt, or China, which have found mention in the speculations of Pythagoras, Aristotle, and Epicurus—re-echoed in Lucretius—or a few remarks made by Strabo on cosmography, we would scarcely know that the natural history of the earth had awakened thought or inquiry. There is a want of verified certainty in any references made to the *data* on which geology exerts research.

The birth-year of Napoleon and Wellington (1769) is that also of Baron Cuvier and William Smith, the men to whom a scientific theory of the earth presented itself as at once desirable and possible, the former of whom has been designated as the originator of palæontology, and the latter greeted by the Geological Society as "the father of English geology." It is not to be supposed that there were no students of the life of the globe before scientific geology was introduced. The sciences which treat of matter and the phenomena of organic nature could scarcely have been pursued at all without bringing into view some of the changes which take place in the solid crust of the earth, and into notice some of the more remarkable facts regarding the organic life of the past; but these things had not been singled out as peculiar elements of investigation, and no distinctly arranged science of observation had made them its special study. It was in 1769, too, that Goldsmith began his five years' labour on "The History of the Earth and of Animated Nature" (published 1774). In it he gives "a review of the different theories of the earth," and so shows, by his history of opinions on that subject, that speculation had been awakened, though it had not yet presented to science any positive results.

One of the contributories to geology is agriculture. It requires an intimate knowledge of different soils, and as these depend upon the nature of the substances which compose them, the natural varieties of culturable surface presented in the diversified aspect of the country must have attracted attention and excited thought regarding the relations of fertility and of cropping not only to the upper soil, but to the under soil as well. Dr. Lister, in 1683, saw this, and suggested to the Royal Society the production of a map of the soils of England. Miners must have in their experience acquired a considerable familiarity with the succession of the strata through which they sought the hidden treasures of coal or metal, and quarrymen could scarcely avoid collecting a large mass of information on the kinds and qualities of the stones among which they worked. Potters and brickmakers, to whom a knowledge of clays was valuable, would have a traditionary collection of ideas on the properties of those kinds of earth which afford plastic material for their fictile arts. Thus the practical industries aid scientific observation. As early as 1546 George Agricola had published, in folio, at Basel, a work, embodying the results of the study of years in the mining districts of Saxony, on the formation of rocks and minerals through the agency of water and fire, on mineral waters and lava, and on fossils of animals found in the earth. Cuvier said, "What Conrad Gesner was to geology, Agricola was to mineralogy." Germany provided three and Sweden five systems of mineralogy between 1730 and 1762, but these only incidentally give detached information concerning the mode in which minerals form part of the earth's crust. In 1743 Packe, in a "Choragraphical Chart of East Kent," embodied a large amount of well-arranged practical knowledge without scientific coherence. Tylas, a Swede, in 1750, and Lehman, a German, in 1756, suggested and exemplified the idea of a regular order prevalent in the superposition of the layers of the surface of the earth. A. G. Werner, among the mineralogists of Saxony, gained the experience which he generalized into his "System of Geognosy," or a classification of rock-formations and inferences as to their origin, with which his name is associated, which he issued in 1780. Mitchell, the Woodwardian professor of geology at Cambridge, set in order several important observations on the general relations between the physical aspects and the geological structure of the globe. John Whitehurst, in his "Inquiry into the Original State and Formation of the Earth" (1778), was both an observer and a theorist, and he embraced in his book, which ran through three editions, the experiences of the miners and colliers of Derbyshire regarding the sequence of strata in that county, remarkable for the romantic scenery of its mountains, valleys, and caverns, and the mineral wealth of its geological treasures.

It does not comport with our purpose to introduce references to any speculations that may justly be called extra-geological. But we must mention the line of thought in which Fracastoro, Cardan, Palissy, Colonna, and Scilla engaged in explanation of the organic fossils found buried in the earth.


GEOLOGICAL MAP
OF THE
BRITISH ISLES.
FRAGMENTAL ROCKS
TERTIARY
SECONDARY
Cretaceous
Wealden
Jurassic
Triassic
PRIMARY
6. Permian
5. Carboniferous
4. Devonian or Old Red Sandstone
3. Silurian
2. Cambrian
FRAGMENTO-CRYSTALLINE
Gneiss etc. of Highlands
CRYSTALLINE IGNEOUS
Granite and Syenite
Basalt, Trap etc.
Archaian
ORKNEY Is
Nth Ronaldsay
Westray
Sanday
Stronsa
Mainland
Hoy Waas
Sth Ronaldsay
C. Wrath
Thurso
Wick
Dornoch Firth
Tain
Murray Firth
Elgin
Banff
Kinnairds Hd
Dingwall
Inverness
Huntley
Aberdeen
Kincardine
Montrose
Forfar
Perth
Kinross
Firth of Forth
Stirling
Glasgow
EDINBURGH
Berwick
Peebles
Lanark
Selkirk
Ayr
Dumfries
Newcastle
Durham
Carlisle
R. Tees
Appleby
Flamborough Hd
York
Lancaster
R. Humber
Liverpool
Lincoln
Chester
Derby
Boston
The Wash
Nottingham
Stafford
Leicester
Norwich
Shrewsbury
Birmingham
Huntingdon
Cambridge
Warwick
Worcester
Hereford
Bedford
Ipswich
Buckingham
Hertford
Gloucester
Oxford
LONDON
Thames
Reading
Maidstone
Canterbury
Guildford
Dover
Salisbury
Winchester
Chichester
Southampton
Str. of Dover
Beachy Hd
Dorchester
I. of Wight
Portland Bill
Exeter
Barnstaple
Launceston
Start Pt
Falmouth
Lands End
Scilly Is
Lundy I.
Bristol Channel
Bristol
Wells
Cardiff
Neath
Monmouth
Brecon
Caermarthen
Pembroke
Aberystwith
Caernarvon
Holyhead
St Asaph
HEBRIDES OR WESTERN ISLES
Harris
Nth Uist
Sth Uist
Barra
Rum I.
Coll I.
Tiree
Mull
Islay
Malin Hd
Donegal
Donegal Bay
L. Neagh
Antrim
Belfast
Armagh
Enniskillen
Sligo
Achil I.
Castlebar
Cavan
Dundalk
Longford
Tuam
L. Derg
Galway
Galway B.
Athlone
DUBLIN
Kildare
Wicklow
Ennis
Limerick
Mth of the Shannon
Kilkenny
Tralee
Wexford
Waterford
Cork
Cork Harbr
C. Clear
IRISH SEA
ST GEORGES CHANNEL
NORTH SEA
ENGLISH CHANNEL
SCOTLAND
IRELAND
ENGLAND
WALES

They regarded them as real forms, not produced by a freak of nature in the play of plastic force, but as true organic remains inhumed by a general deluge. Dr. Plot accepted the theory of an occult originating cause rather than that of an ordinary and natural one. Dr. Wotton abridged Scilla's work for the *Philosophical Transactions*. Dr. Lister expressed a doubt that the fossils were different from their living types. Dr. John Ray, in an essay on "Chaos and Creation" (1692), and Woodward, founder of the Cambridge professorship of geology, in his "Natural History of the Earth" (1695), after examination of the shelly formations, take the part of the advocates of a natural cause for organic fossils, although the latter ascribed their dispersion to a universal deluge. Ray and Hooke looked to earthquake forces for a solution, and a short time thereafter the localized question of fossil remains was merged in a far wider series of general speculations on the nature, origin, and phenomena of the exterior surface of the earth. Theories of the formation of the globe became intensely controversial, and a large and singular literature arose which had for its object the explanation of geological data, so as to reconcile Scripture and geology. Into these controversies we need not enter. Leibnitz sought to set the question in a form fitted to scientific consideration. Lazzaro Moro strove to recall speculation from playing with fancies to accurate observation of facts. Buffon was eclectic, and would have combined the suggestions of Leibnitz with the faith in experience advocated by Ray. The theory of James Hutton was proposed to explain the actual phenomena visible on and in the crust of the earth, and confined itself to that. His was called the Plutonian system, because he ascribed the origin of the granites and porphyries to igneous causes, as opposed to the Neptunian system of Werner, who held that all the chief strata were due to aqueous influences.

The era of controversial geology was long and active, and its effects are felt in the history of the progress of thought even now. Theories of the birth of worlds, and of the changes which have occurred in them, were formed and advocated or combated in real or supposed relation to creeds and beliefs, rather than from full acquaintance with and fair statement of the actual facts on which every theory ought primarily to depend. The deductive reasoning of the olden time, which laid down premises and drew conclusions from them which were intended to serve as explanations of the experiences by which men were impressed, was, however, giving place in investigative research to the inductive form of philosophizing, which sought diligently and carefully for a thorough knowledge and an accurate record of the realities of experience as the indispensable basis of any pertinent theorizing. Science unites fact and idea into truth. We must never neglect facts, we must ever attach supreme importance to ideas. In their antithesis lies falsehood, in their agreement truth. In the age of discussion these were unequally yoked together. They should have modified and moulded each other. But, on the contrary, they struggled against being even formally united. Men had aspired to be architects of systems before (and without) the materials being at hand to construct what they wished, and neglectful of the co-operative activity required to provide and prepare the stones of the building. At length it came to be understood that an explanation of the phenomena of the universe is only possible, as a science, when observation has supplied a real knowledge of facts. Then inductive geology came into being, and Baron Cuvier brought before men, in his "Discourse upon the Revolutions of the Surface of the Globe," what he called "a slight sketch, a first glance cast upon the mighty creations of antique times;" and William Smith almost simultaneously furnished a "Geological Map of England, Wales, and part of Scotland," and lectured in York on the identification of geological strata, and the means of determining their succession afforded by the fossils imbedded in them. He was the earliest geological geographer, and the first to furnish such an aid to study as may be seen in the "Geological Map of the British Isles" which forms one of our Plates.

Sagacity, inventiveness, and genius are excellent endowments, but unless we have a firm grasp of facts—facts exactly as we know them, and in regard to which nothing is assumed —we cannot elicit true knowledge merely through these powers of thought. Conceptions which include and combine like facts in distinctness and intelligibility are required to secure scientific progress. The phenomena of geology must be known. Its facts must be arranged into essential and accidental, and these must be marked by well-understood names, either common or technical, in order that all that is merely accidental may be laid aside, and the proper likeness of all that is essential may be bound together into a oneness of idea such as may always denote the special idea. Happy guesses, clever hypotheses, finely set-off theories, do not constitute science, though sometimes they may help to flash a light upon the path of thought. But verification of facts, and the arrangement of them in order and degree, are more useful than they. Smith's great merit was that he rested his whole system on exact knowledge, and refused to seek insight except through sight. He was bent on reading the rock-leaves of nature's volume for his lessons of wisdom, and on getting the meaning direct from the source of all genuine knowledge.

Smith, as we may all do, began at home. He, when a lad, collected punddibs (*tenebatulæ*) and pound-stones (*echinites*), —fossils which, all unwitting of their nature, the dairywomen used as weights and the ploughboys as quoits—and carved sundials on the soft brown oven-stone of the district of Churchhill. He was naturally inclined to land-surveying, and gladly became apprenticed to that profession in Stow-on-the-Wold. The oölites (limestones) of Oxford and Gloucester, the lias and red marl of Worcester, and the coal of the New Forest districts became familiar to him. He modelled the strata of a coal country. While engaged in executing surveys and levellings for canals he united the inquiries of the geologist with the business of an engineer, and he became convinced, after a journey of 900 miles as a canal surveyor, that there was a settled order of succession among strata, and mapped out, as we have already mentioned, the geological distribution of stratified rocks. Notions, too, of the nature of the organic remains found in the different strata arose in his mind, and he formed the opinion that "each stratum had been successively the bed of the sea and contained the mineralized monuments of the races of organic beings then in existence." This brings us to the important geological topic—stratification—a subject which is probably the most important in the science of geology.

The immediate surface of the earth is commonly a covering of vegetable mould. When we dig through this soil we usually come to clay, sand, gravel, chalk, lime, coal, or granite, though in some places we may require to dig pretty deeply before we reach these more solid materials. These are, however, not mixed confusedly together, but are ordinarily found in special districts, not in insulated patches scattered here and there, but in continuous stretches. If we notice what we see in our own neighbourhoods, we shall find that some hard stone of one kind or other underlies the mixed material of the soil. The chalk of the Yorkshire wolds may be traced (see Map) through Lincoln, Norfolk, Suffolk, Bedford, Wilts, and Dorset. Limestone ranges may be followed through Lincoln, Northampton, Gloucester, and Somerset, and parallel ranges of lime and sandstone may be observed. In a journey from the insular group of hills, rising steeply from Bassenthwaite Lake, of which Skiddaw is the chief, where a peculiar slate abounds, the route towards London will pass through districts in which limestone, iron, coal, red and blue clays, oölitic ranges, clayey vales, chalk hills, and gravelly plains meet the eye in succession. Passing from London, along the Thames towards Oxford, we have a long slope of chalk hill, then we cross vales of clay and standstone, climb a limestone range, proceed through blue and red marl, get into the coal and iron districts, and reach the region of the slaty Snowdon. In Scotland, to the north of the broad valley of Strathmore and the confluent depressions into which it passes near Lochlomond, the old red sandstone, granite, gneiss, mica, and clay slate with quartz, occupy the whole field; while to the south of it the great coal measures—pierced occasionally and overlaid with products of an igneous origin—fill up a hollow from sea to sea. Further to the

south the red sandstone shows itself again, and the Silurian formations stretch from seaboard to seaboard. Hence arise the variety and beauty of the scenery of Scotland.

The regular manner in which the different kinds of rock appear suggest that they hold some definite relations to one another, and when experience has been aroused to a sense of this we find that in mines, pits, wells, quarries, canal and railway cuttings, and other works of industry which require the laying bare of the subsoil and inner matter of the earth's upper crust, a similar set of relations manifest themselves. It is plain that these rocks are arranged in layers, distinguishable from each other by very marked characters, lying parallel to one another, and that in a certain determinate order, which is never inverted, however disturbed. These layers are called strata.

Anyone whose path has led him along the steep hill's edge, through a precipitous valley, or along a shelving sea-wall, is familiar with the fact that they show distinct evidence of the principle of stratification. In these we have, as it were, nature's own geological sections exhibiting to our eyes the phenomena of stratification in the correlated layers of limestones, sandstones, clays, and slates, piled one upon another in regular order, seen in different places occupying the same relative positions, and all displaying the same general fact, that the principle of stratification is and has been effective among the operations of nature. If we exercise a little attention in our observations we shall perceive that there is no chaotic confusion in the mode in which these strata occur; they are so arranged that their succession is definite and discernible. A certain order prevails among them, and such layers as are found in any one geological position beneath another is not found in any case above it, even in another place. They may be omitted: they are never misplaced. The set of beds is found in regular succession, though members of the series may not be present and visible.

The next point which regulated observation and registered experience have made certain is that the order of the superposition of strata is regular. All the different members of a definite series do not occur together. Very seldom, indeed, are more than three or four members of any given series seen in one place. But many observations made in different countries, and in places widely apart from one another, have been carefully compared, arranged, and verified, so as to supply a combined view of the entire experiences of investigators, and so the order of succession has been determined. The order of certain of them has been perceived at one place; of a few more, at another. The upper strata in the former, it might be, was ascertained to be the lowest of the latter; the lowest in that collection was observed as the uppermost in a third locality; and in like manner the whole range of the strata was fixed. It was as if, for instance, in the letters of the alphabet, one set ran from A to G, another from G to M, a third from M to S, and a fourth from S to Z. This order being always observed, if K, for instance, were to appear at the top we would know that D could not be among the underlying members, and that if T presented itself to view N would not be got by any search for the rest. A group of strata having the same character of deposit and the same period of subsidence is styled a formation. Layers may have many laminæ (or levels of deposit), and formations may have several strata; laminæ may be less or more compacted and coherent (*i.e.* coalescent); but strata, though in some cases adherent, do not so firmly cohere as laminæ do. The whole series of stratified rocks in England have now been, with verified exactness, laid down in geological maps, and other countries are gradually following up in this practical form the example set to them; all these representative epitomes of the rock-formations of different countries support and substantiate this theory of stratification and the law of the superposition of strata.

Thus we have a distinct phenomenon before us. How is it to be explained? It implies that these layers have been somehow spread out and laid down horizontally, one over another, so as to be superimposed in regular sequence. Such a phenomenon we observe taking place in the deposits which are formed at the bottom of lakes into which streamlets carrying muddy sediment—the denuded soil of the hill-slopes—flow, or on the sea-margins and at large estuaries where the water is laden with pulverized matter. These rocks, which cover so much of the earth's surface, if composed of material formed by the abrasion of other rocks mixed with and suspended in water, would so have arranged and settled themselves when the water which held these matters in solution had become calm. The different constituents of the rocks would depend on the kind of rocks abraded, washed down, and arranged by gradual subsidence to the bottom. The heaviest part of the matter would, of course, sink most readily, the less weighty would fall next, and that which was lighter still would continue longer in suspension. At length, however, layer by layer the entire material would be deposited, and if from any cause the water receded or was drawn off and the solid matter were left bare, the deposits, if dug through, would show this succession of layers. Each of these different beds of the same sort of deposit would constitute a layer, and be called a stratum. The superimposed masses of matter should, if this be the real manner of their formation, accord with this experience and show the material most apt to sink occupying the lowest place among stratified rocks. This is the case. Besides this, the reasonableness of this solution is collaterally substantiated by these two circumstances—(1) the deposits frequently present the appearance of having been formed while there was a ripple on the water, as in the Portland stone of Boulogne; and (2) the remains of aquatic shells, plants, and animals are found in a perfect state of preservation in deposits far from any known sea. Hence the aqueous origin and sedimentary formation of the stratified rocks is regarded as an established fact scientifically explained.

Besides this stratification by mechanical deposition, such as we see in sandstones, clays, &c., we may have formations, like the limestones, resulting from chemical precipitation. Water is both a mechanical and a chemical factor in geologic change. In certain circumstances, at different temperatures, and by the help of various agents—acids or alkalies—a number of other substances may be held in solution in water. When, however, by change of temperature, by evaporation, or alteration in the ingredients, the substances formerly contained in it are no longer able to be retained, but separate and fall down, they form a sediment to which the name of a precipitate is given. Of stratified precipitates, such as limestone, composed of carbonate of lime and magnesia, or salt rocks consisting of muriate of soda, it seems to be certain that we have analogies in the calcareous marls, and the accumulations of limestone and of salt which are to be found in lakes, at river mouths, and by sea-margins. We infer, therefore, that the older strata were in all likelihood the results of deposition occurring through chemical action taking place by the agency of water spread over large spaces of the surface of the globe. As, generally, different strata are distinguished one from the other by their mineral constituents, the parts of a series may usually be pretty clearly recognized by a skilled observer, though not always; and a trained mind may thereby estimate the probable condition of the land and water while the deposits or precipitates were taking form, fashion, and place.

Water as a mechanical motor-force is well known. Its effects are seen in the removal from one place to another of pebbles, sand, and clay, of stones, which by abrasion and attrition give evidence of removal and transport. We cannot doubt, therefore, when we see strata composed of earthy materials, differing in coarseness and fineness, and some even of unequal coarseness or fineness, as clays, sandstones, and conglomerates, that water has exerted its carrying power. On the whole we may safely accept the idea that the whole series of strata is the ultimate result of many changes of aqueous agency, mechanical and chemical, and that layer by layer, and rock-formation after rock-formation, were laid down by repeated yet successive depositions and precipitations from a watery investuring mass.

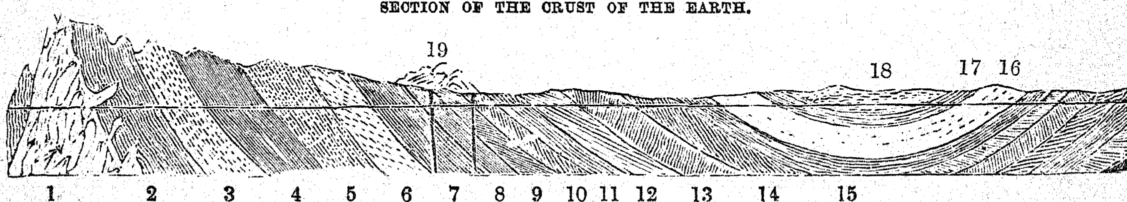
These considerations do not close up and round off investigation. They rather re-excite thought. Did the mechanical action of water, while the deposition of its contents by subsidence went on, operate in a continuous or an intermittent manner? Or did the chemical activities work towards precipi-

cation briefly and interruptedly, or over a long stretch of time with some constancy of effort? Appearances seem to show that mechanical stratification was sometimes temporary and local, while the chemical operations were almost always of slow operation and more equable in their way and time of working.

We cannot enter here into the questions raised regarding geologic time. That will come up when we require to note and remark upon the condition of the organic remains which are found in the successive series of the strata. It will be enough here to call attention to the plainness with which the foregoing statement accounts for the phenomena of *alternation* and of *gradation.* It sometimes happens when strata are in contact—limestone, say, lying upon sandstone—that while the limestone above and the sandstone below are "unmixed with baser matter," there is an intermediate set of beds composed of alternate layers of—as in the instance adopted—sandstone and limestone. In other cases we have a gradual passing of one stratum almost imperceptibly into another. For instance, the Oxford clay of the coast of Yorkshire shades so completely yet gradually into the calcareous grit, that the bluish colour passes off without any hard and fast line into the solid, yellow, coarser grained, siliciously cemented grit above it. The same consideration explains why all strata are not coextensive. The beds of sandstone, with coal, which are interposed in the oolitic systems of Yorkshire may almost be said to be wedge-shaped; a little south-east of Whitby, near Robin Hood's Bay, they are 500 feet thick, but as they proceed south before reaching the Derwent they have entirely disappeared. Sometimes a similar change occurs on both sides of the interposed strata, and then the appearance is designated lenticular (or lens-shaped).

All stratification is not, however, parallel and regular throughout the entire mass of a given formation, still less is it universal throughout the entire mass of the materials of the external crust of the earth. Over wide plains and gently undulating districts the phenomena of stratification are such as may have occurred by mechanical deposition or chemical precipitation; but what of the oblique slopes of hillsides and the contorted strata of such valleys as Chamouni and the Lauterbrunnen, and the vertical strata of the Ingleborough carboniferous limestone, or the almost vertical strata of loose sand and pebbles which give magnificence to the scenery of the Isle of Wight? Cuvier said, "All strata must necessarily have been formed horizontal," and Smith's illustration of stratification resembling the position of slices of bread and butter laid upon a plate, seems to imply the same idea. We have, however, plain evidence that many strata are not level but bevelled, that some are inclined at high angles, and some are almost perpendicular. We hear of faults and dykes, of dislocation and unconformity of strata. The phenomena of elevation and disruption are "open and apparent." We have in Silurian districts, and in the coal measures of Somerset, with their overlying strata, instances of one rock lying on the upraised wave-worn edges of another. We know that earthquakes do occur and that volcanoes do erupt. All true. Stratification is one explanation of the phenomena of the outer surface of the earth. It shows how from the waste and detritus of continents there have come into existence broad and thick contemporaneous deposits, in what we might call the form of slush, and that these deposits, mechanically or chemically, separated from the mass of waters dispersed and scattered far and wide from the layers which we can easily see lying superposed on one another. But the idea of stratigraphical succession does not solve the whole mystery. We have to reckon, too, with the forces of "frost and fire." The former, as congelation and expansion, works wonderful changes in rock and earth, and the latter, as conflagration and as melting power, is an active agent in changing surface and succession. Thus we have to take into consideration the chemical processes consequent on volcanic and similar powers exerted in the metamorphism of rock; and so we have brought before us, in the aspects of nature, phenomena of a different kind which also require to have their true meaning unfolded. These necessitate the consideration of igneous agency and the disturbing powers of fire. To the phenomena of igneous rocks we shall next direct attention. In the meantime, the following section of the crust of the earth will afford material for study, observation, and thought.

SECTION OF THE CRUST OF THE EARTH.



1, Granite. 2, Gneiss. 3, Mica slate. 4, Clay slate. 5, Silurian rocks. 6, Old Red Sandstone. 7, Mountain limestone. 8, Lower coal formation. 9, Upper coal formation. 10, Lias. 11, Lower Oolite. 12, Middle Oolite. 13, Upper Oolite. 14, Wealden. 15, Greensand. 16. Chalk. 17, Tertiary strata. 18, Recent formation. 19. Trap.

ALGEBRA.—CHAPTER I.

ADDITION AND SUBTRACTION.

ADDITION is the putting of two or more magnitudes or quantities together. As an algebraical process, it signifies the most convenient method of collecting together such quantities as are to be added, so that they may be counted, reckoned, and summed up in the same manner as the parts of which they consist. It is therefore the bringing together the sum of various quantities into one united expression, and so into one simple quantity, or if it must be into a compound quantity it presents that quantity in its simplest form. Quantities are magnitudes that are, or at least can be, supposed to be expressed in numbers. The definition of $+$ (*plus*), the sign of addition, is that it signifies *increased by*, and that of subtraction $-$ (*minus*), *decreased by.* Of the arithmetical outcome of addition and subtraction, however, algebra affords no example. In it, these processes are to a large extent rather indicated than performed. Thus a quantity is, in algebra, said to be added when it is joined to another by the sign $+$, and subtracted when joined to another by the sign $-$; as, $2x+3x=5x$. This is the case though x signifies houses, fields, horses, cows, or coins; $7x-5x=2x$, whether x stands for apples, pears, nuts, marbles, or pounds. But if x in the one case stood for horses and in the other for marbles, no addition of them in any algebraical sense could be performed. Hence algebraists make three cases of addition—

1. When all the terms are like (*i.e.* similar—not different at all) and have the same sign.
2. When all the terms are like terms, but have different (*i.e.* not all the same) signs.
3. When all the terms are unlike (*i.e.* dissimilar) terms.

When no sign is expressed $+$ is understood.

In the *first* case the rule is:—Add the numerical coefficients, prefix the common sign, and affix the letter or letters common to all; as—

$$4a+6a+a+5a=16a;\ -2b-b-7b-9b=-19b.$$

Of this operation the following examples may be given:—

$$
\begin{array}{lrrrrrrrr}
(1) & 4a & -\ 8a & 7a^2 & -6a^2 & 4b^2 & -\ c & bx^2 & -2\ a+x^2 \\
 & a & -11a & a^2 & -\ a^2 & b^2 & -\ 5c & 3bx^2 & -5\ a+x^2 \\
 & 5a & -\ a & 9a^2 & -\ a^2 & 9b^2 & -12c & 10bx^2 & -1\tfrac{1}{2}a+x^2 \\
 & 3a & -\ 5a & 2a^2 & -5a^2 & 7b^2 & -\ 3c & 3bx^2 & -3\ a+x^2 \\
\hline
 & 13a & -25a & 19a^2 & -13a^2 & 21b^2 & -21c & 17bx^2 & -11\tfrac{1}{2}a+x^2
\end{array}
$$

The same process may be gone over with each, only altering the signs, *i.e.* putting minus ($-$) before those which have now no sign, and to which therefore plus ($+$) is understood, and putting no sign before those to which the sign $-$ is here given.

After the same fashion these sums may be worked:—

(1) $6ac+5ac+3ac+ac+11ac=26ac$. (2) $-7ab-4ab-3ab-2ab-ab-7ab=-24ab$. (3) $2x+3a-4b$; $3x+2a-5b$; $4x+8a-7b$; $9x+4a-6b$; $5x+7a-9b=23x+24a-31b$.

In the *second* case:—Add all the positive (*i.e. plus*) numerical coefficients into one separate sum, and all the negative (*i.e. minus*) numerical coefficients into another separate sum, subtract the less from the greater of the two sums; prefix the sign of the greater, and affix the letter or letters common to all; as $6x-x-3x+3x=9x-4x=5x$; $-12xy+7xy+xy-9xy=-21xy+8xy=-13xy$. Here it will, of course, be seen that both addition and subtraction are employed in finding the sum.

On looking carefully over the following examples, the working will be clearly seen:—

$$
\begin{array}{r}
4ay-x^2 \\
13ay-3x^2 \\
-11ay+2x^2 \\
-\ 2ay+2x^2 \\
\hline
4ay
\end{array}
$$

Here we find two $+x^2$ terms amounting to $4x^2$, and two $-x^2$ terms amounting to $-4x^2$. These thus cancel, pay off, or equalize each other. Then we have two $-ay$ terms amounting to $13ay$, and two $+ay$ terms amounting to $17ay$. Hence, subtracting $13ay$ from $17ay$, we have $4ay$.

$$
\begin{array}{rrrrr}
-\ 9ax & 7xy & -4bx^2 & 3a^2b^2 & 4x^2-3y^2 \\
-12ax & -8xy & -5bx^2 & -15a^2b^2 & 2x^2+\ y^2 \\
ax & xy & 6bx^2 & -\ 3a^2b^2 & x^2+3y^2 \\
7ax & -5xy & 3bx^2 & 5a^2b^2 & -5x^2+2y^2 \\
\hline
-13ax & -5xy & 0 & -10a^2b^2 & 2x^2+3y^2
\end{array}
$$

These same sums may be worked with the signs respectively altered.

In the *third* case:—Collect all the differing quantities into one line, putting their proper signs to each; as, Required the sum of x, $7a$, $2b$, $2a-3b$; *Ans.* $7a+2a-3b+2b+x$; or *condensing* $7a+2a$ into one expression, and $-3b+2b$ into another, it would stand $9a-b+x$.

It must now be mentioned that when all the terms of any expression are joined by the sign $+$ it makes little or no matter in what order they are placed; as, $9+7$ and $7+9$ yield the same result, 16; similarly, $a+b$ and $b+a$ give the same result, whatever sum we may regard a and b respectively as representing. In like manner $a+b+c$ may be written, if required, either as $c+b+a$, $b+a+c$, $c+a+b$, $a+c+b$, or $b+c+a$, for the value of an algebraic expression by convention (*i.e.* general agreement) remains the same, in whatever order the terms in which it is expressed are arranged.

The following example, fully explained, should make this matter easily understood.

$$
\begin{array}{c}
4x^2-2xy+1-3y+4x^3. \\
4y+3x^3-y^2+xy-x^2. \\
5x^3-2x+y-15+y^2.
\end{array}
$$

Here we collect $4x^3+5x^3$ and $3x^3=12x^3$

$$
\begin{array}{llll}
\text{Then } 4x^2 \text{ and } -x^2= & +3x^2 & & \\
-y^2+y^2 \text{ cancel each other} & & & \\
-2xy+xy \text{ leaves} & & -xy & \\
+4y+y-3y \text{ leaves} & & & +2y \\
-15+1 \text{ leaves} & & & -14 \\
\text{to which we require to add} & & & -2x.
\end{array}
$$

The answer would probably be best arranged thus—

$$12x^3+3x^2-2x-xy+2y-14.$$

Suppose now we have $5x+2b+6b$ to add, the *answer* is $5x+8b$; $5x-2$ and $3x+7$, *answer* $8x+5$; $3a-2b$ and $5b-a$, *answer* $2a+3b$. Again, $7a-3a+15a+a-5a-2a=23a-10a$, *answer* $13a$; $4a+2b-3c$ and $3a-6b+d=7a-4b-3c+d$.

These are all exceedingly simple illustrations of the principles of addition.

It must have been noticed by the attentive student that the working of these questions differs in no way in reality from the operations performed under the similar rule in arithmetic, and that it only seems more complicated from the indications made by letters of the special quantities or magnitudes whose amounts require to be discovered through these summations. Such operations will arise in the progress of his algebraic experience, and it is well that he should familiarize himself with these and similar questions.

It is, however, in a mathematical sense strictly true that no operations in addition or subtraction are really performed, they are merely indicated. A quantity a is said to be added to another quantity P when we use the expression $P+a$, and similarly a is said to be subtracted from P when we say $P-a$. If we give to these expressions a particular value, *e.g.* $P=12$, $a=5$, $P+a$ will equal $12+5=17$, and $P-a=12-5=7$. If now to the sum $P+a$ we add a, we have a fresh sum $P+a+a$. We may not know at all the value of a, but we know that whatever its value is, it is to be added twice to P. The sum $P+a+a$ is therefore equal to $P+2a$, and this number is called the coefficient of a, indicating the number of times it requires to be added to P. Similarly, the expression $P+a+a+a+a=P+4a$ and $P+b+b+b=P+3b$, where a has the coefficient 4 and b the coefficient 3.

Again, if $4a$ and $6a$ be added to P, and $5a$ and $2a$ be subtracted from the same, the whole result will be expressed by

$$P+4a+6a-5a-2a.$$

Here, whatever may be the value of a, we know that it is added $4+6$ or 10 times, and subtracted $5+2$ or 7 times. Consequently, we might write instead of the above expression,

$$P+10a-7a, \text{ and this is } P+3a,$$

for, without inquiring into the value of a, it is clear that to add it 10 times, and subtract it 7 times, is in effect to add it three times; that is, to write $3a$ for $10a-7a$.

This process of combining several *like terms* into one may be called *Reduction*. From the preceding example it will be observed that Reduction consists (1) in collecting together those coefficients which have the same sign into one sum, (2) those which have the opposite sign into another, (3) subtracting that which is numerically less from that which is numerically greater, and (4) prefixing the sign of the greater sum to the difference. Thus,

$$
\begin{array}{l|l}
P+3a+2a-4a=P+a & P-12x+9x+2x=P-x \\
P+x\ +7x-2x=P+6x & P-\ 6a+3a-6a=P-9a.
\end{array}
$$

When no two terms of an expression are exactly the same as to letters and the number of letters in them, the reduction cannot be carried further. For instance, $ab+ac$ does not admit of reduction, although a be common to both terms; the same is also true of $a+aa$, which is neither $2a$, nor $2aa$. The reason of this will be subsequently explained.

Since we cannot take a greater number from a less, any expression such as $3a-4a$ is impossible; for, whatever $3a$ may be in value, $4a$ must be greater. As such expressions frequently arise in the solution of questions, we may find it necessary to investigate the meaning of them; but, in the meantime, we may regard them simply as directions to do what cannot be done. Such an expression as $a-2a+3a$ is, however, possible; it is merely an improper form of $a+3a-2a$, which, reduced, is $2a$.

When an expression such as $b+c$ is inclosed in brackets, it signifies that its whole result stands in relation to the symbols connected with it as if it were only one letter. Thus, $a+(b+c)$ means that we are to add to a not only b, but $b+c$. Now, adding b and then c, the sum is $a+b+c$. In

like manner, the expression $a+(b-c)$, signifies that we are to add to a, not b, but a quantity less than b by a quantity c. To find the sum, we must therefore first add b, and afterwards subtract c, whence we get

$$a+(b-c)=a+b-c.$$

From this and the preceding instance we conclude that *an expression in brackets preceded by the sign + will not be altered in value if the brackets be struck out.* They, besides, furnish us with a general rule for the addition of algebraical expressions. It is this:—Connect all the terms of the given quantities by their respective signs, and make all the reductions which are practicable. It must, however, be remembered, that when a quantity is not preceded by any sign, + is always understood, and when a literal quantity has no coefficient, 1 is always understood. Thus, a is the same as $+1a$. The following is an example of reduction and addition:—

Add $a-b$, $a+2b-c$, $2a+2b-3c$, $2a+3b+4c$, and $2c-3b$ together.

Ans. $a-b+a+2b-c+2a+2b-3c+2a+3b+4c+2c-3b$, which, by reduction, becomes $6a+3b+2c$.

When the quantities to be added are complex, the process of reduction is much facilitated by writing the *similar* terms in vertical columns. The foregoing example is thus arranged on the right, and the reduced sum is found by setting down the value of each column. In arranging the terms in this manner, the only care necessary to be taken is to preserve to each term its proper sign. This may give rise to improper forms of expression, such as $-3b+2c$, but will introduce no error into the final result; for in this arrangement the terms have reference only to the columns in which they are placed, and it is obvious that the columns themselves may be disposed of in any order. In arranging the columns, the alphabetical order of the letters is commonly preferred.

Terms arranged.

$$\begin{array}{r} a-b \\ a+2b-c \\ 2a+2b-3c \\ 2a+3b+4c \\ -3b+2c \\ \hline \text{Sum, } 6a+3b+2c \end{array}$$

It has been shown that an expression in brackets, when preceded by the sign +, admits of the brackets being struck out without the value of the expression being affected; but if the bracketed expression be preceded by the sign −, the case is different. Let the expression be $a-(b+c)$. Here we are required to subtract from a, not b, but the sum of b and c. If then we subtract b, making $a-b$, the expression is too great by c; hence c must also be subtracted, giving

$$a-(b+c)=a-b-c.$$

Again, let the expression be $a-(b-c)$; if we now subtract b, giving $a-b$, we will have subtracted too much by c, for it is not b which we are required to subtract, but a quantity less than b by the quantity c. Consequently, $a-b+c$ is the true result, or

$$a-(b-c)=a-b+c.$$

From this we learn that *when an expression in brackets is preceded by the sign −, the brackets may be struck out,* IF THE SIGNS OF ALL THE TERMS WITHIN THE BRACKETS BE CHANGED, *namely,* + *into* − *and* − *into* +. This rule leads directly to the mode of subtracting expressions which have more than one term. For, applying the remark respecting the relation of quantities put within brackets, we may obviously, in the first instance, express the given subtraction in that form, and afterwards strike out the brackets, and change the signs as directed above. Thus, suppose that it is required to subtract $a+b+c-d$ from P; the subtraction is indicated by

$$\text{P}-(a+b+c-d),$$

which becomes, when the brackets are struck out and the signs changed,

$$\text{P}-a-b-c+d.$$

Similarly, let it be required to subtract $5a-5b+6c$ from $6a-3b+4c$; the expression is

$$6a-3b+4c-(5a-5b+6c),$$

and taking away the brackets, we get

$$6a-3b+4c-5a+5b-6c,$$

which, by reduction of like terms, becomes $a+2b-2c$.

The following, then, is the rule for Subtraction:—

Change the signs of all the terms of the quantity to be subtracted (considering + as the sign of the first term), and annex the expression thus changed to the expression from which the subtraction was to be made, and make all practicable reductions, as in addition. To facilitate reduction, the like terms of the two expressions may be written under each other, as in the following examples:—

$$\begin{array}{llll} \text{From} & 4a+3b-3c & \quad & 5m-7p+2r-3x \\ \text{Take} & 3a-3b+4c & & 8m+2p+2r-5x-z \\ \hline \text{Rem.} & a+6b-7c & & -3m-7p\qquad +2x+z \end{array}$$

This last result we prefer writing in the form

$$2x-3m-7p+z, \text{ or } 2x+z-7p-3m,$$

as the + sign is understood when not expressed, but the sign − must always be expressed when a quantity is affected by it.

The student may arrange the following question for himself:—

$$\begin{array}{ll} \text{From} & 8a-5b-3c-7d+5e-8f+3g+17k+3h-q \\ \text{Take} & 3c-2p-5b+2d-7f-5e+3h+\ 9g-5k+12 \\ \hline \text{Rem.} & 8a-6c-9d+10e-f-6g+22k+2p-q\ \ -12 \end{array}$$

As the results in addition and subtraction are independent of the order in which the terms of the expressions are written, it is not necessary to inquire whether an expression be written in a possible or impossible form. Thus it would be immaterial in either of the operations whether we wrote $2-5+7$, or $2+7-5$; the rules apply equally to either form, and the final result is not affected.

EXERCISES.—ADDITION.

1. Add together $15x+a$ and $18x+b$. Here $15x$ added to $18x$ will give $33x$. The expression must consist of a, b. But a, b, and x are unlike quantities. All, therefore, we can do is to represent them in our addition by the sign +; we therefore write the answer $32x+a+b$.

2. Add $12a-x$ to $11a-2x$. Here we first take notice of the a terms. Our result is $23a$; but from that quantity x and $2x$ are to be subtracted. Therefore $3x$ is to be subtracted from $23a$, and the result is $23a-3x$.

3. Add $12a-2x$ to $12x-4a$. The sum of the first term in each is $12a+12x$; but from one of these we must subtract $2x$, and from the other $4a$. It requires no consideration to show that any diminution of one of the quantities to be added must cause an exactly equal diminution in the whole result; consequently our process requires only that we subtract $2x$ and $4a$ successively from $12x$ and $13a$; therefore $8a+10x$ is the sum sought.

4. Add $12a-15x$ to $6x-7a$. By adding the first terms in each quantity we get $12a+6x$, from which we must subtract $7a$ and $15x$. If we perform the first subtraction, it remains that from $5a+6x$ is to be subtracted $15x$. Now, if our operation consisted merely in subtracting $6x$, the result would be $5a$; but having done this there still remains $9x$ to be subtracted. That operation cannot be done; it can only be indicated, so that the result is $5a-9x$.

5. To $12a+7x+8y$ add $4a-9x-7y$. *Ans.* $16a-2x+y$.

6. To $7a+7x+2y$ add $3y-17x-18a$. *Ans.* $5y-10x-11a$. In this example the order of the quantities has been transposed, by our writing y first in the final result.

$$\begin{array}{rr} \text{7.} & 5a+7x-3y \\ & 2a+2x-\ y \\ & a-3x+5y \\ & 6x-2x-\ y \\ \hline & 14a+4x\qquad \end{array} \qquad \begin{array}{rr} \text{8.} & x+\ y+\ z-\ a \\ & x-\ y+\ z+\ a \\ & x+\ y-\ z+\ a \\ & -x+\ y+\ z+\ a \\ \hline & 2x+2y+2z+2a \end{array}$$

$$\begin{array}{rr} \text{9.} & a^2x-\ ax^2-\ x^2 \\ & ax-\ \ x^2-\ a^2 \\ & -2ax^2-2a^2x-2a^2 \\ & -3a^2x+3ax^2+3a^2 \\ \hline & -4a^2x-2x^2\ +ax \end{array}$$

SUBTRACTION.

1. From $7x^2+9y^2$ subtract $4x^2+3y^2$. Subtracting $4x^2$ from the first quantity there remains $3x^2+9y^2$, from which, when we subtract $3y^2$, the result or answer is $3x^2+6y^2$.

2. From $4a+8b+15c+19d$ subtract $2c+d+7b+4a$. We begin with the a's, and the remainder is 0. The result is $8b+15c+19d$. Taking $7b$ from this quantity, the remainder is $b+15c+19d$. Next, $2c$ subtracted from this leaves $b+13c+19d$. From this we finally take d, and $b+13c+18d$ is the actual remainder.

3. From $6a-9x$ take $4a-5x$. If we were to subtract $4a$ only, we should have subtracted too much by $5x$. Hence to rectify the error we must add $5x$ to this result. The first result is $2a-9x$, which has therefore to be increased by $5x$. But $2a$ first lessened by $9x$ and afterwards increased by $5x$ is the same as $2a$ lessened only by $4x$; therefore $2a-4x$ is the remainder.

4. Subtract $5a-3b-2c$ from $8a-4b-c$. In this case we say $8a-4b-c-5a+3b+2c=3a-b+c$, answer.

5. From $a+b+c-d-e$ take $x+y-v-z$. By subtracting $x+y$ the remainder is $a+b+c-d-e-x-y$, and there has been subtracted too much by $v+z$. Hence we must add $v+z$ to the result, and get $a+b+c-d-e-x-y+v+z$. This result shows the *positive* terms of the subtrahend changed into negative terms in the result, and the negative terms of the subtrahend into positive ones.

6.
$$\begin{array}{r} a-x+2y-3z+w \\ 2x+3a-y+z-w \\ \hline -2a-3x+3y-4z+2w \end{array}$$

7.
$$\begin{array}{r} 4-7y+z \\ x+y+z \\ \hline 4-8y-x \end{array}$$

8.
$$\begin{array}{r} a-(x-a)=2a-x \\ x-(a-x)-x-a \\ \hline 3a-3x \end{array}$$

9.
$$\begin{array}{l} 25a^2-16x^2+14ax-15a^2x-12ax^2+x^3 \\ 15x-12a^2-16ax-25a^2x+x^3-16x^2 \\ \hline 37a^2+30ax+10a^2x-12ax^2-15x \end{array}$$

ASTRONOMY.—CHAPTER II.

THE SUN—SOLAR PARALLAX—METHOD OF DETERMINATION—NUMERICAL DATA—SOLAR LIGHT AND HEAT—SOLAR GRAVITATION—SUN SPOTS—DISTRIBUTION—DURATION—MAGNITUDE—PERIODICITY—CONNECTION BETWEEN PERIODICITY AND MAGNETIC PHENOMENA—PHYSICAL NATURE OF SUN SPOTS—SOLAR PROMINENCES.

In a treatise on descriptive astronomy, the sun, the centre of our planetary system, naturally commands attention first, not only because its immense mass regulates the motions of all the various bodies which revolve around it as a centre, but also because the mean distance of the earth from the sun is taken as the general unit of astronomical measurements. The value of this measurement is determined by observations of transits of the planet Venus across the sun's disc [see planet Venus], which gives the amount of the sun's *equatorial horizontal parallax*, or the angular measure of the earth's equatorial semi-diameter as seen from the sun's centre, the earth being at its mean distance from the sun. The result of various observations of the transit of Venus, and a re-determination from a series of meridian observations of Mars at its opposition, made in 1862 at Greenwich, and Victoria, New South Wales, and the transits of Venus in 1874 and 1882, give as the most reliable results, that the sun at mean distance subtends an angle of 32′ 3·6″, and with a parallax of 8′ ·94″ its actual diameter is 852,692 miles.

Hitherto no sensible compression has been detected on the mass of the sun similar to the polar depression on our earth. The surface of this enormous sphere is therefore 11,614 times that of the earth, and the volume 1,251,570 times; since the surfaces of spheres are to each other as the squares of their diameters, and the volumes as the cubes. The sun's mass, and consequently its attractive power, exceeds that of the earth 314,049 times, and is approximately 742 times the masses of all the planets put together. It is difficult to conceive the meaning of such enormous magnitudes. Perhaps the immensity of the sun's mass may be comprehended by reference to the moon's distance from the earth. The moon is distant from the earth by a space equal to sixty-four times the earth's radius. If the earth could be supposed to be placed within the centre of the sphere of the sun, not only would there be space for the entire lunar orbit round the earth within the vast solar sphere, but at least forty-eight more radii of the earth would require to be added to the lunar orbit in order to reach the external surface of the sun's mass. By comparing the volumes of the sun and the earth, and bringing in the value of the masses, the specific gravity or density of the two is obtained. The sun's volume exceeds that of the earth in the ratio of 1,251,570 to 1; the sun's mass exceeds the earth's in the smaller ratio of 314,049 to 1. The density of the sun is to the density of the earth, therefore, as 314,049 to 1,251,570, or in round figures as 1 to 4. The density of the earth, as compared with water, being taken as 5·67, the density of the sun is 1·42 by the same standard. The most compact coal has a specific gravity of 1·36, that of phosphorus is 1·77. The weight of the sun is therefore little more than that of a globe of coal of the same dimensions, and considerably less than that of a globe of phosphorus.

TABULAR STATEMENT OF VOLUMES AND MASSES OF THE SUN AND PLANETS.

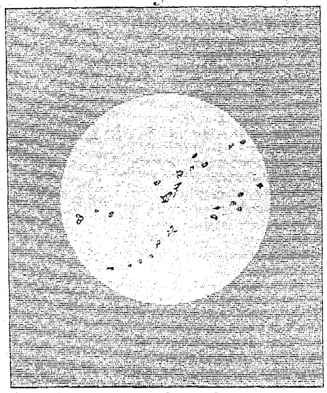
	Diameters. The Equatorial Diameter of the Earth=1.	Volumes. The Volume of the Earth=1.	Masses. The Earth's Mass =1.	Densities. That of the Earth =1.	Weight at the Surface of the Earth =1
The Sun, .	108·135	1,273,000	325,000	0·251	27·366
Jupiter, .	11·117	1,231	305	0·247	2·465
Saturn, . .	9·490	685	91	0·195	1·105
Neptune, .	4·390	85	18	0·211	0·953
Uranus, .	4·205	74	16	0·216	0·883
The Earth,	1·000	1·000	1·000	1·000	1·000
Venus, . .	0·954	0·874	0·776	0·887	0·942
Mars, . .	0·536	0·154	0·111	0·720	0·382
Mercury, .	0·373	0·052	0·076	0·142	0·540
The Moon, .	0·273	0·020	0·012	0·600	0·164

The volume of the sun is therefore more than 600 times larger than that of all the planets together, and the specific gravity or density of the four larger planets very closely approaches to that of the sun, while the four planets of medium size and the moon have a mean density of 0·940, or nearly four times that of the sun. The stupendous mass of the sun would naturally increase the intensity of gravitation at its surface. A body set free in space at the surface of the earth falls about 16·1 feet in the first second of time, with a velocity increasing during each succeeding second [see "Gravitation," NATURAL PHILOSOPHY]. A body similarly set free at the surface of the sun would have at the end of a second a velocity 27·366 times that of a body falling at the surface of the earth, or of 872 feet per second, the space travelled over in the first second being the half, or 436 feet. This is equivalent to saying that bodies on the sun's surface must weigh twenty-seven times as much as upon the surface of the earth. On the earth the centrifugal force developed by the rotation of our globe diminishes the weight of bodies in a proportion which goes on increasing as the equator is approached. At the equator the total diminution is $\frac{1}{289}$. Upon the sun the centrifugal force at the equator is only about $\frac{1}{18000}$ part of the force of gravity. The sun would require to turn upon its axis with a speed 133 times greater than it does to counterbalance the effects of gravitation at its surface and wholly deprive a body of weight. In the case of the earth, a speed of rotation seventeen times as great as at present would deprive all bodies on the equator of our globe of their weight. It is this very small amount of centrifugal force at the sun's equator, compared to the intensity of gravitation at its surface, which suffices to explain the absence of appreciable polar compression in the case of the sun's disc, all the diameters of which, measured from

ASTRONOMY.

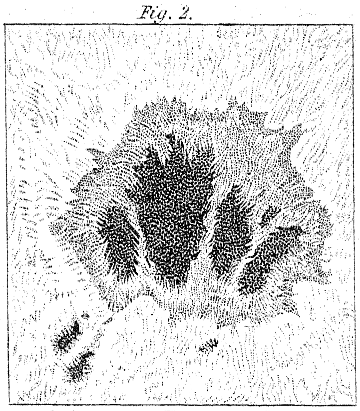
THE SUN —— SOLAR SPOTS.

Fig. 1.



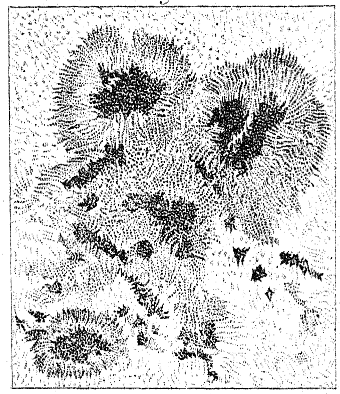
Telescopic view of the Sun, with Sunspots.

Fig. 2.



A Sun spot. Luminous Bridges.

Fig. 3.



Group of spots.

Fig. 4.

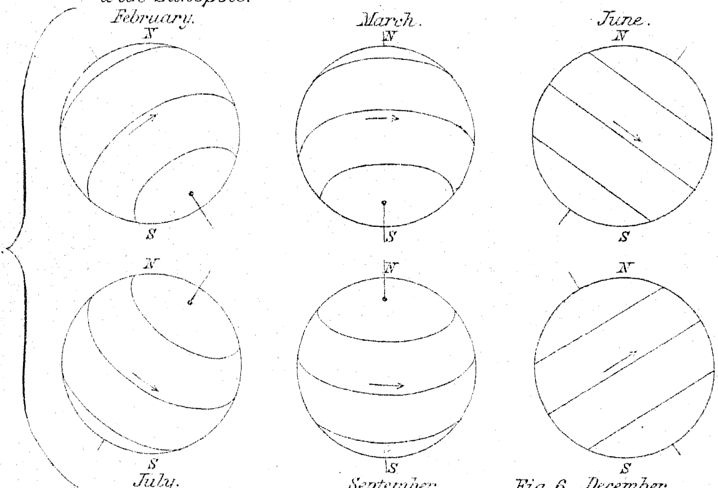
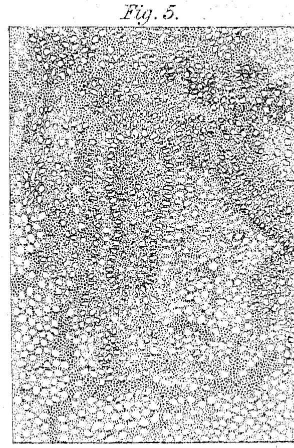
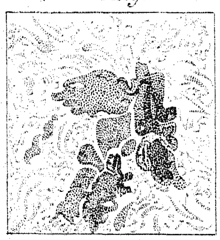


Fig. 5.

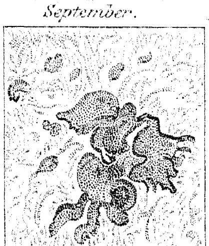


Pores on surface of Solar Disc.

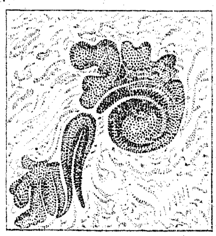
Fig. 6.



Sun Spot 27 Oct.



Same Spot 29 Oct.

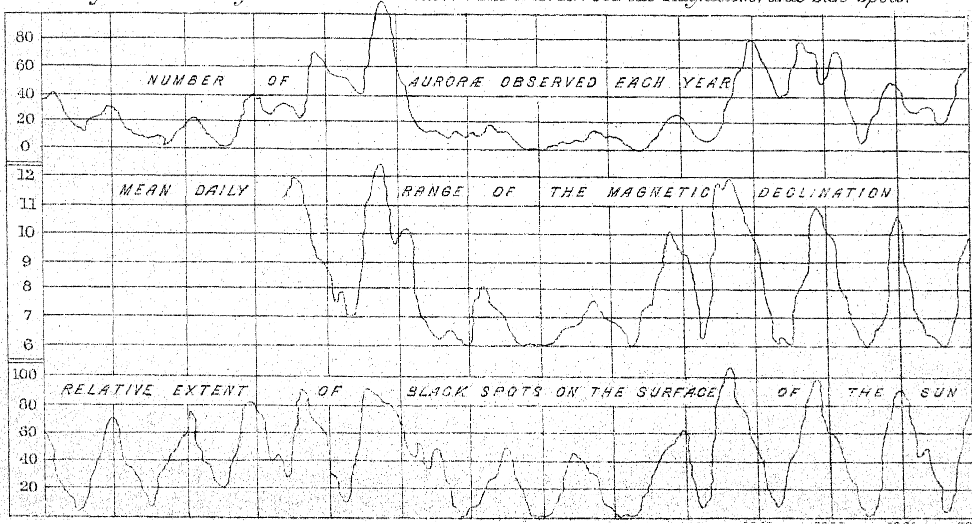


Same Spot 31 Oct.

Same Spot 2 Nov.

Fig. 7.

Diagram Illustrating the Connection between Auroræ, Terrestrial Magnetism, and Sun Spots.



the earth, appear to be perfectly equal to each other. The sun, in its relation to the various bodies which revolve round it, may be regarded as fixed. Therefore the sun rising and the sun setting, or the sun moving through the signs of the zodiac once a year, is purely conventional language. It is the earth that moves, and not the sun, the apparent motion of the sun being an optical illusion.

The sphere of the sun is surrounded by an extensive and highly rarefied atmosphere, self-luminous and the origin of the light and heat transmitted to our earth, both of which are certainly transmitted through space beyond the planet Neptune, and therefore emanate in all directions around the sun in an immense sphere of over 5,400,000,000 miles in diameter. Of this vast amount of light and heat emitted by the sun, it has been calculated that our earth only receives $\frac{1}{2381000000}$ part. The chemical and heating influences of the solar radiations will be found fully described under the section on NATURAL PHILOSOPHY ("Light and Heat").

On examining the sun's disc with a telescope, there may frequently be observed about its equatorial zones dark spots or *maculæ* (Lat. *macula*, a blemish), fig. 1, Plate III. Each of these is surrounded by a fringe of a lighter shade, termed a *penumbra* (Lat. *pene*, almost, and *umbra* a shadow), the two not dissolving into each other by successive tints, but abruptly (fig. 2). Sometimes several spots have been observed included in one penumbra (fig. 3), and sometimes an umbra without a penumbra; and the reverse have been noted, though these latter may be considered exceptional, and probably closely related to physical changes just commencing or terminating on the sun's visible surface. In all cases there is a marked contrast between the luminosity of the penumbra and that of the general surface of the sun adjacent. Towards their exterior edge the penumbræ are in general darker than nearer the centre, and as a rule they are very irregular in their outlines. Sun spots are for the most part confined to a zone extending 35 degrees or so on each side of the solar equator. They are neither permanent in their form, nor stationary in their position, and frequently appear and disappear with great rapidity. Sun spots are rarely seen directly under the sun's equator, or nearer to it than 8 degrees of north or south latitude; between 8 and 20 degrees is their general range. They are always more numerous and of larger general magnitude in the northern hemisphere; the zone between 11 and 15 degrees north is generally noted for large and persistent spots. Where the groups of spots are very straggling, the line joining their extreme ends is generally found to lie more or less parallel to the equator, extending across nearly the entire visible disc. These circumstances, Sir John Herschel suggests, "point to evident physical peculiarities in certain parts of the sun's sphere more favourable than in others to the production of spots on the one hand, and on the other to a general influence of its rotation on its axis, as a determining cause in their distribution and arrangement, and would appear indicative of a system of movements in the fluids which constitute its luminous surface, bearing no remote analogy to our trade-winds, from whatever cause arising." The observations of Carrington tend to show that as the epoch of minimum distribution of spots on the sun's surface approaches, the spots manifest a distinct tendency to approach the equatorial regions, leaving their previous positions above the parallels of 20 degrees or so. On the minimum period passing, a sudden change appears to set in, the equatorial regions being almost deserted by the spots, which on their reappearance are chiefly found in parallels above 20 degrees. At present the regularity of this movement has not been determined. The duration of individual spots is very variable. Some remain visible for several months, others scarcely for as many minutes; a few days or weeks is commonly the extent of permanency. Some spots are formed and disappear during the period of a single transit, rather over twelve and a half days; others, again, remain during several successive transits. As the spots are fixed, or nearly so, on the sun's surface, no spot can remain continuously in sight for longer than the semi-duration of the sun's rotation on its axis. A spot when observed for any length of time, will first be noticed on the sun's eastern edge or "limb," disappearing in little less than a fortnight on the western limb; in about another fortnight, the spot, if still in existence, will reappear on the eastern limb, and in the same manner traverse the solar disc again. These phenomena clearly point to the rotation of the mass of the sun on its axis; and from observations made, the period of this rotation has been variously fixed at 25 days 8 hours 10 minutes, 25 days 9 hours 7 minutes, and 25 days 7 hours 48 minutes. These differences are accounted for by the difficulties of observations due to the transitory forms and actual proper motions of the spots. The entire period, 27 days 7 hours, required by a spot to make a complete visual rotation, is longer than that of the sun's actual rotation, owing to the earth's progressive movement in its orbit. As regards the proper motion of sun spots, the observations of Carrington and others determine that the spots have a proper motion of their own, and that this proper motion varies systematically with the latitudes of the spots. The varying position of the earth with regard to the sun, combined with the inclination of the sun's axis to the plane of the ecliptic, amounting to 82° 45′ according to Carrington, and 83° 5′ according to Spörer, causes the earth in its annual revolution to be sometimes above the plane of the sun's equator, when the spots appear to describe ellipses, the concavity of which is turned towards the northern pole of the sun, and sometimes below it, when the sun's southern pole is viewed, the concavity being then turned the opposite way. In two points of the earth's orbit diametrically opposed to each other, the earth is in the plane of the sun's equator, and these points are termed *nodes;* one being the ascending, the other the descending node. At these periods, about 4th June and 6th December, the courses described by the spots appear to be straight lines, as in fig. 4, Plate III. Consequently from June to December the courses of the spots form concave lines towards the north pole of the sun, and from December to June they appear concave towards the south pole. If the luminous surface of the sun is represented by 1000 when the earth is at its mean distance, the same surface will be represented by the numbers 967 and 1035 when the earth is in *aphelion*, or at its furthest point from the sun in July, and in *perihelion*, or nearest the sun in January, respectively.

Sun spots often possess many individual peculiarities, sometimes assuming coloured tints, and the penumbræ appearing as made up of a multitude of black dots, usually radiating in straight lines from the umbra. Frequently sun spots are of vast dimensions and visible to the naked eye. In 1828 a spot was measured, and computed to have an area of about four times the entire surface of the earth. In June, 1843, a spot was observed of some 75,000 miles in diameter. On 15th March, 1858, a spot was observed having a breadth from west to east of 106,000 miles, and on September in the same year also, one having a breadth from west to east of 142,000 miles. The origin of a spot is usually traceable to some of those minute *pores* or dots which appear to stipple the sun's surface, and which begin to increase and assume an umbral blackness, gradually acquiring a visible and at first very irregular and changeable shape. After attaining some measurable size the penumbra begins to form, from which circumstance the theory that the spot originates in a disturbance from below upwards is strongly supported. As the spots decay they become bridged over, the umbræ divide, diminish in extent, and close up, leaving the penumbræ, which in turn also contract and disappear. Fig. 5, Plate III., shows the pores or granulations on the surface of the solar disc as seen by Huggins. Fig. 6 shows the changes observed in the same sun spot on four successive days in October, 1865. One of the most curious and interesting discoveries of modern astronomy is that of the periodicity of the solar spots—namely, that the spots are subject to a periodical variation in prevalence to the amount of about ten years. During this time their numbers follow a cycle, which has a maximum and a minimum. At the minima periods on many days no spots are seen. A very remarkable discovery or coincidence has resulted from this periodicity of the sun spots—namely, that the diurnal variation in the declination of the magnetic needle is characterized by a ten-year period, and that the epoch of maximum variation of the compass corresponds with that of the maximum prevalence of sun spots, and *vice versâ*. It is

also now accepted that auroræ and magnetic earth-currents [see "Terrestrial Magnetism," NATURAL PHILOSOPHY] have likewise a ten-year period, and that their maxima and minima correspond with those of the sun spots. No explanation can at present be given regarding the bond which connects sun spots with magnetic disturbances, but the reality of the coincidences will be seen by the curves (fig. 7, Plate III.) taken from Loomis. The general question of the influence of the sun upon the meteorology of the earth has at present received comparatively little attention. Although, in the words of Arago, "in these matters we must be careful not to generalize until we have amassed a large number of observations," the investigations made by meteorologists appear to justify the conclusion that some relationship exists between solar spots and terrestrial cloudiness and rainfall, and the general deduction that the rainfall tends to rise above the mean when the sun spot area is in excess, and to fall below it when there is a deficiency of solar activity. Regarding the physical nature of the spots little is positively known; all that as yet appears certain is that the nucleus of a spot is lower than the penumbra, and that both are beneath the level of the solar photosphere. Again, detached masses of luminous matter are seen actually to cross a spot without producing any alteration in it; and it also seems that the gases in the space occupied by a spot are at an appreciably lower temperature than those in the brighter parts of the sun's disc. Practically these facts represent the sum of our actual knowledge. That movements of a cyclonic nature sometimes occur on the sun is indicated by drawings made by Secchi on 5th May, 1857, of a sun spot in which a spiral motion evidently existed.

It is now strongly suspected that above these atmospheres of the sun a thin and gaseous envelope exists, somewhat analogous to the atmospheric envelope which surrounds the earth. This theory is confirmed to a certain extent by the fact that the margin of the sun's disc is in general less luminous than the centre. Laplace gives the ratio of the luminosity of the sun's disc at the edge and at the centre at 30 to 48. Vogel, the most recent investigator, obtained by a photographic process the following results. Taking the sun's radius at 12 and the brightness at the centre at 100, the brightness diminished as follows:—Centre=100, 4=96, 8=77, 10=51; edge=13. The chemical rays given out by different parts of the surface of the sun appear likewise to be of unequal power; but, unlike the rays of light, they do not vary regularly from centre to edge of the disc. The heat rays are likewise radiated more from the centre than from the edges. The sun's polar regions are also colder than the equatorial, and the heat radiated from the spots is less than that from the disc generally. The study of solar physics is now a recognized branch of physical astronomy, and by the aid of the spectroscope much new information regarding the physical constitution of the sun has been obtained, which will be noticed under "Spectroscopic Astronomy."

Total eclipses of the sun had long since revealed the fact that the sun was surrounded by appendages of the strangest character (fig. 1, Plate IV.), being enveloped on all sides by a narrow but brilliant ring of intense brightness termed the *corona*, from which stream out in all directions faint rays of light, irregular in length and breadth, and surrounding the moon's limb like a halo. When the total darkness commences the *prominences* make their appearance (fig. 5), cloud-like masses of a red colour, disposed either singly or in groups at various places round the moon's limb. The origin and nature of these appearances were involved in mystery until the spectroscope has shown that these remarkable phenomena belong to the sun, and are nothing but vast accumulations of the luminous gaseous material by which the solar body is wholly surrounded, termed the *chromosphere*. These enormous mountains, principally of luminous hydrogen gas, extend at times beyond the limb of the sun to a height exceeding 80,000 miles (figs. 3, 4, Plate IV.)

The light of the corona is not that of reflected sunlight, since none of the dark lines are contained in its spectrum, and the inference is that the corona is self-luminous and belongs to the sun. The question as to its precise nature is, however, as yet undetermined, although it was found possible in 1883 to photograph it, even without the assistance of an eclipse, by using suitable media to intercept the light from the sun. In the photograph of the corona, fig. 2, Plate IV., the prominences are clearly defined, and also the remarkable rifts or dark spaces in the corona.

The various spectroscopic observations made of the sun lead to the following conclusions regarding its constitution:—The body of the sun, or its light-giving envelope, the photosphere, is completely surrounded by a gaseous envelope in which hydrogen forms the chief element: this is called the chromosphere, and its mean thickness is between 5000 and 7000 miles. The solar prominences are local accumulations of the chromosphere, and therefore chiefly composed of hydrogen gas, which appears to break forth from time to time from the interior of the sun in the form of vast eruptions, forcing their way through the photosphere and chromosphere: this gas is projected with great velocity, and becomes rapidly rarefied, in a direction away from the sun's limb.

Observations of the prominences distinguish them into two forms—*eruptive* and *vaporous* or cloud-like forms. These forms, shown in their natural colours in figs. 3, 4, Plate IV., serve to illustrate the remarkable changes of the prominences in shape. These enormous masses of flaming gas sometimes extend along the sun's limb for a distance of 224,000 miles. In the sun's polar regions prominences occur only occasionally; they are most frequent at about 45° N. lat., in a region where solar spots are rarely seen. The prominences are therefore phenomena quite distinct from sun spots, and are probably intimately connected with the formation of faculæ. The various forms of the prominences prove that they are not of the nature of clouds floating in an atmosphere, but partake of the nature of eruptions from the interior of the sun, and their extreme rapidity of motion necessitates the hypothesis of a repulsive power at work either at the surface or in the mass of the sun.

PENMANSHIP.—CHAPTER II.

SLOPE, SPACE, SHADING, AND COMBINATION.

LANGUAGE is the outward form of thought: writing is the outward form of language. Figured form has been adopted in all civilized communities to indicate by its signs the sounds of the speaking voice. We have already given, in a simple and methodical arrangement, specimens of the figured forms which constitute the small-hand characters of the English alphabet. Exactness of form is essential in penmanship, and elegancy of form gives a very great deal of attractiveness to writing. Dexterity in the formation of letters is not at all incompatible with taste in the manipulatory execution of the various operations required to make one's letters properly. Beauty of penmanship is not a mere luxury, though it excites a high pleasure, and communicates a rare charm. It is an economy of time, trouble, and temper. Fair handwriting is not only agreeable, but easy to read—unless we have mistaken aimless adornment for that choicest of all ornamentation, elegant simplicity of script. There ought to be no mere display of turns, twists, and twirlings in the lines used for writing in business or social communications. In these, beauty is, "when unadorned, adorned the most." Let no one, therefore, hold it "a baseness to write fair;" for it saves their readers from the trouble of trying to make out what has been sent as a message, the time employed in deciphering what ought to have been plain, and the worry of temper arising from finding difficulty in what should have been an easy matter. Those who follow the specific directions formerly supplied for the formation of the letters will find little difficulty in their proper production. One only note of supplementary warning seems to be needed on this particular of form. It is this—that writing is not merely copying or imitating a few forms of less or greater simplicity or complexity of combination of line, link, and curve, but the production in a correct, current, faithful, and elegant style of similar forms with expertness.

Exactitude of form is essential to elegance, and sedulous attention and assiduous practice must be given to acquire the power of precise reproduction of the alphabetical characters.

SOLAR ECLIPSE — RED FLAMES — CORONA — ZODIACAL LIGHT

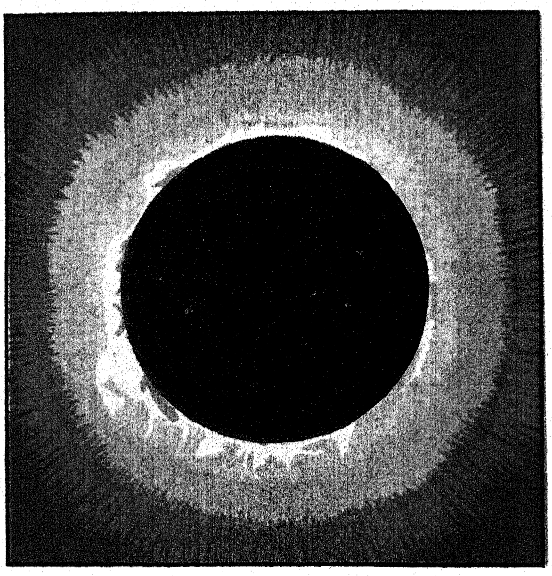


Fig 1 Total Eclipse of the Sun

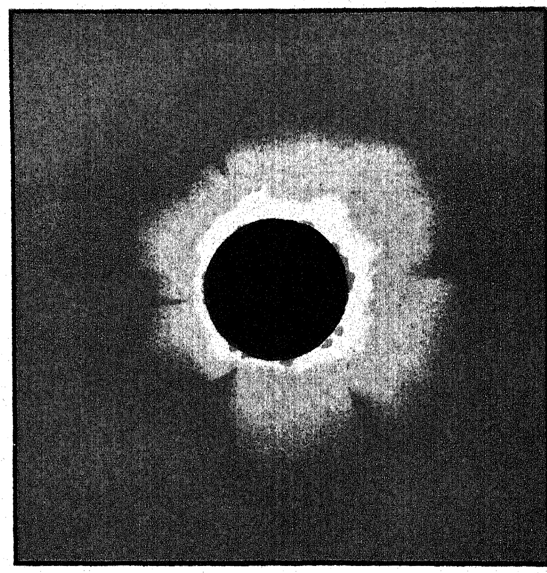


Fig 2 Solar Corona photographed at Syracuse

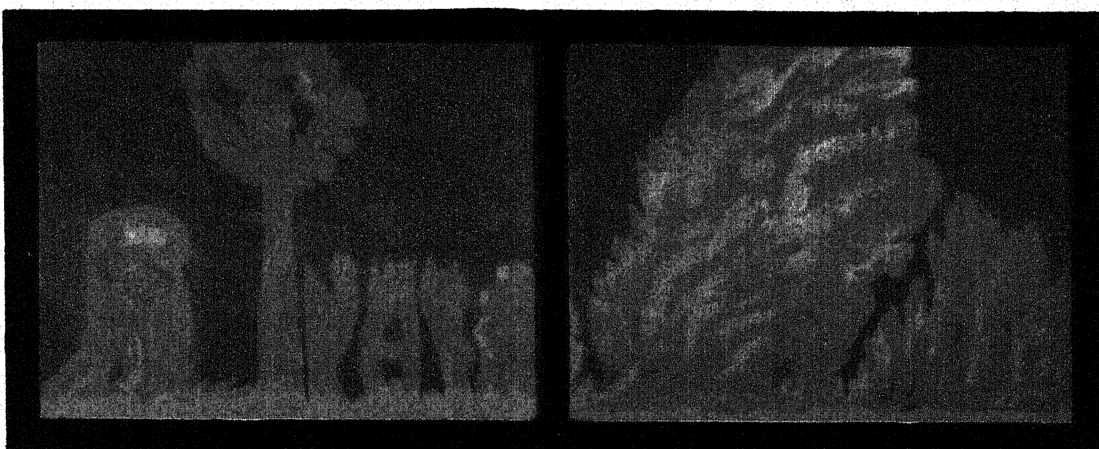


Fig 3. Solar Prominences Fig 4.

Scale ______ 60,000 Miles

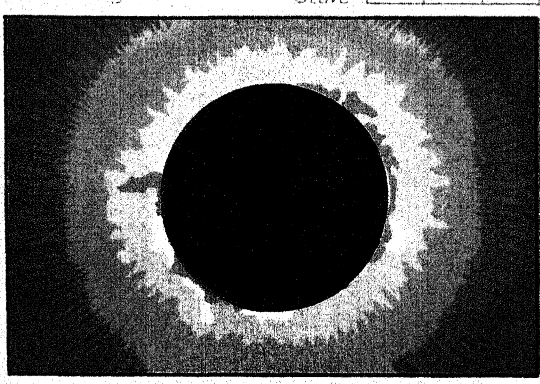


Fig 5 Solar Prominences

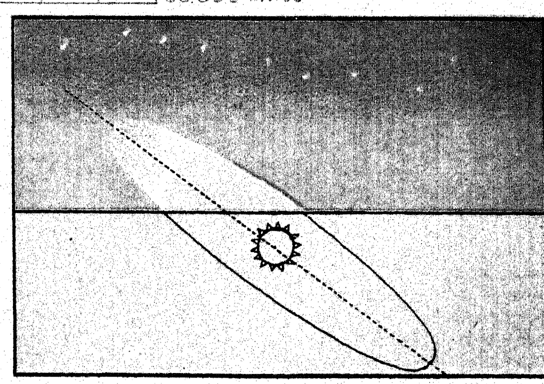


Fig 6 Direction of Axis Zodiacal Light

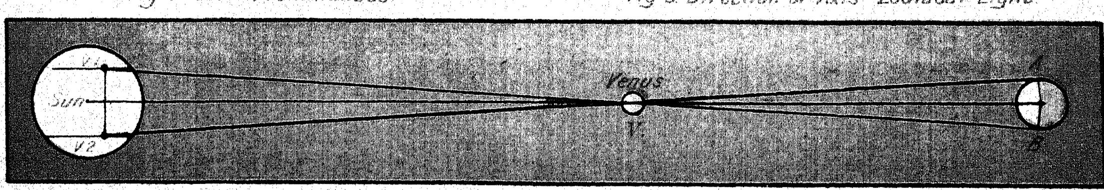


Fig 7 Measure of Suns distance by transit of Venus

This is not to be done by a painful process of bit by bit drawing or painting, stopping often, lifting the pen every here and there, and setting to work again with nerve-numbing repetition and fatiguing enforcement. We need to combine heed and speed. Writing is an artistic accomplishment; but when it impresses the reader with a sense of painfulness of production, it fails in not having attained that highest of all arts—to conceal art. Rapidity and legibility are requisite—ornament even at best is only exquisite. Suppleness of joint, nimbleness of muscle, expertness of nerve, accuracy of eye, dexterity of manipulation, must all be conjoined in penmanship. Every specific stroke should be so diligently practised that it can be accomplished completely and at once. Over each of the elements we require such mastery that the pen will ply sweetly while rounding curve or fashioning loop and turning crochet. When we proceed to the formation of single letters, we should complete each entirely without lift of pen or change of position, and when we have acquired the capacity of producing any letter with one continuous act or effort of hand, it will be found highly advisable to employ some care and practice in running off entire lines of such letters across the page until fluent familiarity results in fair writing. All requisite directions in regard to the form and the method to be employed in the formation of the small letters have been already supplied. We have now to furnish such instructions as may secure elegancy in addition to accuracy of form, when letters are combined into words. These, though they must be treated of separately, are not to be disjoined in practice. They require, for the sake of distinctness, to be dealt with as special elements, but in the future efforts of the penman these disjunct instructions are to be so made, by diligent and persevering practice, incorporate and one as to be brought not only into unison but union. We shall successively bring under the reader's notice (1) slope, (2) space, (3) shading; and shall thereafter proceed to show what will be best adapted to impart elegance to letters in (4) combination.

Slope.—In every specific act of penmanship it is necessary to observe uniformity of slope. Slope, in writing, is that slanting inclination or deflection from a perpendicular drawn at a right angle from the real or imaginary horizontal straight line on which, as a base, the main body of any piece of writing rests, that is found by experience to be (1) easiest for the hand and (2) most pleasant to the eye. The peculiar structure of the right hand, the special mode of the attachment of the arm to the body, and the whole arrangement of the muscles both of hand and arm make it easier (*i.e.* more natural) to draw lines inclining to the right than any others. This is readily seen to be the case from noticing the difficulty with which—until training has habituated it to do otherwise—the right hand makes straight perpendicular lines, and the almost uniform tendency of early efforts at drawing to lean to that side. Some slope may therefore be regarded as, by universal consent, accepted as a characteristic of fluent writing. It is, however, impossible to fix upon any one definite degree of obliqueness as that single and invariable slope which is, in all cases, alone right. Not only do tastes differ as to the degree of angularity which is considered as pleasing, but one particular inclination or slope appears to be more suitable to the ready, rapid, and exact movement of one person's hand than another. In old times the slope of the side of an equilateral triangle was that fixed upon as artistically right and philosophically exact. It is so easy to provide one's self with an absolutely correct guide to such a slope, that it may very well be accepted as a mnemonic of normal inclination, although it may, in practice, be somewhat departed from. Any one who can work (or even have access to figure illustrating) the first problem in the first book of Euclid, may provide himself with this working ideal. Thus, make a straight horizontal line of any length; from the one end of that line A as centre, with the whole distance of its length A B as radius, draw a circle, repeating the same at point B with radius B A. The circles will intersect or cut each other in C, and if the points C, A, B are joined the angle of inclination is found. If this slope is adopted, it is easy to draw parallels having the same angles as guiding lines, and from this it is quite a simple thing to draw guiding lines which shall have a less or greater degree of inclination than this yields. It is quite plain at a glance (see fig. 1) that writing with the slope F B will be much more economical of space than that with a slope like E B. A very slanting style of penmanship causes the hand to travel over a greater space in writing and the eye in reading it, and to be legible it must sweep over a much greater extent of paper than if writing with fairish uprightness. This may be made plain to the eye by the specimens (fig. 2), or by the plain diagram on the side, which shows that the greater the slope of a line between the same parallels the longer the line.

Fig. 1.

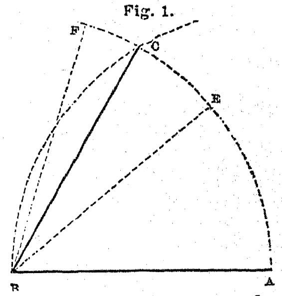
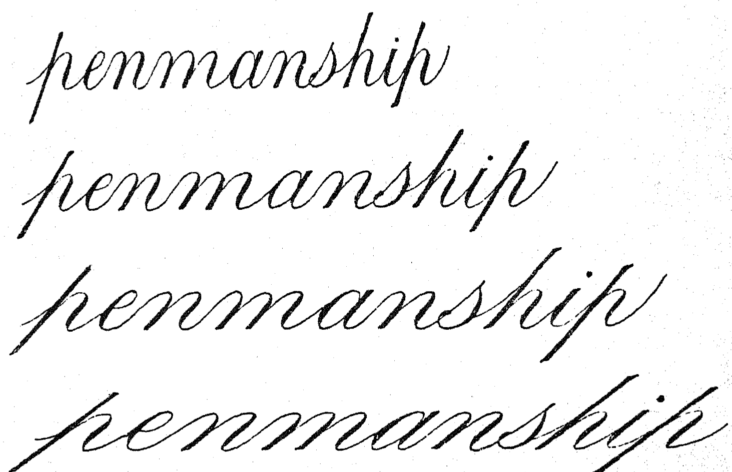
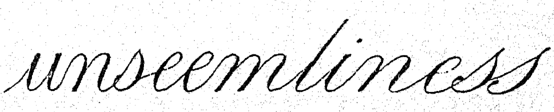


Fig. 2.



We have in Plate I. indicated a slope which is as near an approach to what is most customarily used as a pretty wide acquaintance with handwriting and copy-lines has enabled us to reach; but we recognize the fact that the rhythm of the usual action of the nerves and muscles of the hand and arm, the ordinary habit of sitting while writing, and the customary method of focusing the eyes, all influence the degree of obliqueness given to the lines of letters. These in reality individualize and give specific character to anyone's handwriting. It cannot be doubted, however, that sameness of slope in the same piece of penmanship is an important element in the production of a pleasing specimen, and that any departure from uniformity in the slope employed at the beginning of a specimen of writing annoys the eyes and excites a feeling of unseemliness.



Perpendicularity or bolt-uprightness, as we may call it, is, as a general rule, stiff-looking and suggestive of painful operoseness. An over-angularity of style, while it gives an

impression that the letters are sprawling and ill-balanced, has a tendency to interfere with the proper formation of letters. The balance of economy of space, pleasantness to the majority of eyes, ease of manipulation, and fluent cursiveness of script will probably be found for most people in some such general average of slope as that of which we have endeavoured to provide a fair gauge in Plate I.—to the angular admeasurement given in lines 1 and 2 of which we direct attention as affording fair help towards elegance and symmetricality in writing. We recommend to the student the greatest care in selecting and habituating himself to that position of the body, that disposition of the arm, and that method of holding and handling the pen which, so far as he is concerned, secures the possibility of acquiring the most agreeable and convenient slope in his writing, and the maintaining of a uniform and exact self-sameness of slant in each separate operation in penmanship in which he engages.

Space.—Elegance of penmanship is greatly promoted by attention to spacing. Spacing involves the proper adjustment of the width of letters and the arrangement of all the characters which constitute words in such a way as to secure a precise, proportionate, and adequate distance between each. Not only ought each individual letter to occupy a space exactly proportioned to its size, but each should stand at a proper defined distance from the other. Unless there is a fixed relative and fairly proportionate space assigned to each specific letter, it cannot be produced in correct form, and similarity of distance cannot be secured for each letter in a word. It is obvious that *i*, *b*, *c*, *m*, and *w* cannot be each adequately written within a space of the self-same size, and that the allocation to each of these of exactly the same extent of space would give them the appearance of being very unequally distributed. Let us take, for example, the words milk, wile, and mill-wheel, and form each letter in an equal space. The width of a letter depends a good deal on the degree of slope given to the up-strokes. In an acute angular, or what is usually called a running-hand, considerable obliqueness is given to the up-strokes, and therefore the letters and parts of compound letters are further apart from each other than they are in a less angular style of penmanship. The more upright the handwriting the more nearly do the up-strokes and the down-strokes come to be alike in slant, the more compact the script, and the less in extent is the space occupied by each letter. To fix upon one single distinct invariable unit of letter-space for styles of writing so dissimilar would be nonsensical, while to settle upon any specific definite measure of length as a unit of letter-space would cramp and incommode, besides in all probability it would defeat its purpose and be overrun. Yet to get some distinct, readily appreciable, and easily applicable practical unit and standard, suitable for any style of penmanship, is an important requirement. There is, perhaps, no standard unit of letter-space so readily available and so easily made normal, if once fixed, as that of the letter *u* or *n*. If we reckon the distance between the two upper points of the letter *u* or the two lower ones of the letter *n* as a normal unit for a letter-space, we have an always-at-hand, correct, and workable standard of letter-space for the majority of the characters in the alphabet. Within the space occupied by *u* we can form *n*, *h*, *p*, *b*, *v*, *y*, *o*, *e*, *c*, *a*, *d*, *g*, *q*, *k*, *x*, *s*, *r*, and *z*; in half that space *i*, *j*, *t*, *l*, *f*;

mile will

millwheel

and *m* and *w* will require a space and a half for their proper formation. In this way a uniform measure of letter-space is secured, and its adaptation to each individual style of penmanship is certain and simple.

Besides letter-space, however, we require distance-space. Each letter must be so far apart from its neighbour as to be individualized and distinct. This might be secured by fixing upon a definite space to be left between each letter. Owing, however, to the differences in the form of letters, this rule, simple and apparently satisfactory, does not fulfil the condition of seemliness. The governing consideration in distance-spacing is not that the letters should be absolutely equidistant from each other, but that they should give to the eye the appearance of being so. It is found by experience that certain letters can be placed more closely together, without appearing to be packed, than others, and observation shows that this distinction arises most frequently between straight-lined and curvilinear letters. If we take the normal distance-space as that of *u*, we shall find that between letters formed by a right or a looped line and an upward connective link there ought to intervene one space, as in the cases of the letters *i*, *t*, *l*, *f*, *j*, as

il if ill till jill

Between letters which have a connective slope formed of a terminal link and an initial link a space and a half requires to be allowed in the case of straight-lined and looped letters, as *am*, *ha*, *py*, as in

amper happy

Between letters composed of curves, as *oa*, *od*, *oq*, only half a space occurs, as may be seen in

dog toad food good

In the letters *c*, *e*, when the terminal link is joined to the initial link of another letter, two spaces intervene between the curve of the former and the straight line of the latter, as in

clang cleet

An entire space is left between *o* and any straight-lined letter, as in

tolled told

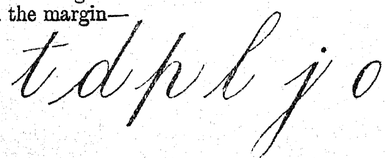
If *b*, *v*, *w*, *x* are joined to curved letters a half space-distance is enough between them; but if they are united to straight-lined letters a whole space intervenes, as in

boat woven

Rules here, however, cannot be made rigidly definite. The eye, when its observation has been quickened and trained, and the hand, when it has been effectively exercised, will do more in a half instinctive manner, as it were, than any amount of general or special laws of admeasurement. The overruling law is that of symmetry, so that a thorough con-

sistency of form and harmony of parts may be seen in the whole of any piece of handwriting. Prior to now applying what has just been said regarding space-distance to the combination of letters into words, it will be necessary to say a few words on a most important element in writing, so far as regards elegance of form and nicety of combination: we refer to shading.

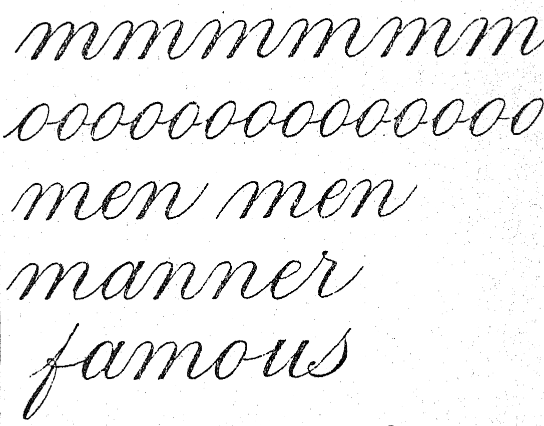
Shade.—In good writing, besides (1) exactness of form, (2) similarity of slope, and (3) uniformity of space-distance, another element is required—(4) fineness of shading. It is true that in speaking of the form of letters we are compelled to use the terms straight and curved lines, and unless otherwise informed a reader or hearer would be quite justified in accepting these phrases as meaning lines of uniform breadth or thickness. The lines of the dexterous penman, whether light or heavy, are seldom of a uniform thickness, but gradually increase or decrease in thickness, with a fine, imperceptible, yet pleasing progression from a full and firm thick line to one tapering off into thinness and fineness, until it receives, owing to its lightness, the name of *hair-stroke.* The student will observe all the varieties of shaded lines requisite for and occurring in small handwriting in the five letters of which specimens appear in the margin—



In the first, *t*, we have an initial hair-stroke connective, a straight line terminating in a distinct square top, and becoming by insensible gradations thinner and lighter until it passes into a hair-stroke, terminal curve, and connective. The straight line of the letter *d* is also shaded similarly. The second type-form, *p*, as given, begins with an initial hair-stroke upward connective slant line, glides into a straight-line formed square at the top, and continued through its entire length of a uniform thickness, terminating solidly square at the lower end, and then, passing into a fine hair-stroke, combining in one a terminal and an initial connective, curving into a straight line, which swells and bellies, as it were, to the thickness of the other main line, and at last imperceptibly diminishes into a hair-stroke, curved, terminal connective. The looped letter *l* commences with an initial connective curving into a narrow oval, all hair-stroke, next forming a long line bulging by gradual increase till it reaches the normal thickness of the letters in the body of any writing, and then decreasing till it fades into a curved hair-stroke terminal connective. The letters *b* and *f* follow the same shading. The long line in *j*, as well as in *y*, *h*, *k*, is shaded by forming the looped-line square at the one extremity and lessening the thickness by degrees till it passes into a hair-stroke. In *o* we have a curved line passing from a hair-stroke into a thickened line in the centre of the curve to the left, and again thinning into a fine upward curve to the right, till the oval is completed by its junction with the commencing stroke.

Shading is done by setting the nib of the pen square if the line to be formed is thick at the top, pressing equably with both teeth, and thereafter, by gently and gradually lessening the pressure, diminishing the line to any fineness that may be required. If the letter is begun with a hair-stroke and is to shade into one, the pressure, which is slight at first, is to be carefully increased until the required thickness has been given, and should then, as gradually and equably as possible, be decreased in an inverse manner. A great deal of careful practice is required to gain that exquisitely graduated sensibility of nerve and dexterity of muscle which are necessary to regulate with due delicacy the singularly slight alteration of the momentum of force exerted in these graphical exercises.

Combination.—On the union of this delicacy of shading and the accurate symmetry of space-distance the excellence and beauty of letters depend. There should be no lifting of the pen in the formation of any word; the hand should glide gently, swiftly, and continuously over the paper, forming the separate elements, not as elements, but as combinations—wholes. The power of doing this delicately, evenly, and continuously will be greatly facilitated by practice in writing in uninterrupted succession across an entire page of paper, line after line, (1) the straight-lined letters *i, u, n, m*; (2) the oval letters *o, c, e, a*; (3) the compound letters *j, l, h, y, d, g, b, q*; and (4) the more difficult forms of *s, r, x, z*, the forms of which are all clearly exhibited in Plate I. If further practice be required to fix the habit of the hand, it may be found



in writing across an entire page such words as man, manner, unmannerly; memoir, memorial, immemorial; come, commune, communion, communicate; imperial, imperious; merchantman, mercantile, unceremoniously, &c.

It is scarcely ever possible, however cunning and lissom the fingers may be, to join words without a patchy and blotched appearance when the hand is lifted and the pen interrupted in its cursive progress. There is no mystic art or occult secret in penmanship. Patience, care, practice, faithfulness of imitation, attention to first principles, observativeness of eye, dexterity of manipulation, continual watchfulness during the currency of the operation of writing, and a firm determination to persevere in the pursuit, with persistent and consistent endeavour to overcome all difficulties and drawbacks, are the requisites of attaining success in penmanship.

LOGIC.—CHAPTER II.

SIMPLE APPREHENSION—SENSATION—NAMES—CATEGORIES—CLASSIFICATION AND DEFINITION.

THOUGHT is a product. The knowledge and experience of the outward world require to be brought into relation with the thinking mind, and by this union of two diverse things thought is originated. Experience outside of the mind which has not reached the intellect is not thought. It must notify the mind of its existence, the mind must take note of it; and then a notion is formed in the mind of that which experience has presented to it. Mind is not thought. Prior to its being stirred by experience of its own nature or impressed by the nature and qualities of the things around it, it is a mere power possessing the possibility, as yet unexercised, of receiving and retaining information from the forms of outer things. It is an apprehensive, perceptive capacity. Experience impresses it, reflection takes place in it, knowledge is present in it. It has done what it ought—exerted its capacity—and thought is the result. All thinking consists in acquiring a knowledge of things, their qualities, properties, relations, implications, causes, and effects. Apprehension is the name given by logicians to the exercised power of knowing things as objects of thought. Experience presents itself to the mind through the senses as sensation; the mind represents these sensations to itself in ideas, and registers its impressions in names. Thus a *phenomenon*—appearance presented from without—is recognized by a *nomen*, a name representing it within. When it is so cognized or known as to be recognized by a name, the mind has attained to a consciousness of it, and as an *idea* reckons it among perceptions and as an *object* among conceptions. Conceptions are the results of many perceptions making their mark upon the conscious mind, originating a notion, and requiring a name, *i.e.* a denoting

word. The following table gathers up the characteristics of notions:—

Notions, as conceptions, may be	1. Clear,	1. Undefinable. 2. Definable.	1. Inadequate. 2. Adequate.
	2. Obscure,	. . . . . .	1. Symbolical. 2. Notative.

A name unites a thing and a thought into oneness in the mind. Knowledge is experience brought under the view and into the power of the mind—that is, knowledge is understood fact.

SIMPLE APPREHENSION—NAMES.

Simple apprehension is the mental power by which sensations are transformed into ideas, and these ideas or concepts are registered and made intellectually transferable by names.

Names note, denote, and connote. They are, first, marks of what has been experienced; second, the means by which we mark off or distinguish one class of experiences from another; and third, the form in which we imply the inclusion of many qualities in one whole, and the exclusion of many qualities from that whole. Names are of four classes, viz.:—(1) Names of states of consciousness, *i.e.* of the feelings or experiences originating in and known by ourselves, *e.g.* sensations, emotions, volitions, and ideas. (2) Substances or existences regarded as real and self-manifesting to our minds—as true, distinct, and less or more permanent things. The external causes from which we receive our sensations of real things in themselves, as distinguished from ourselves as centres of feelings, states of consciousness, &c., and the recipients of the impressions of objects, are thought of as substances. (3) Attributes, as, for instance, (*a*) the qualities, properties, and powers which distinguish substances one from another, and are by us accounted as dwelling in and belonging to them; (*b*) the relations and correlations of substances one to another in place or space, in time, in form or in activity, in regard to likeness or unlikeness, antecedence and consequence, priority and succession, simultaneity or concomitance, &c.; (*c*) the quantity or relative proportions of things or their attributes and feelings or their impressions. (4) Names which designate our own minds. These are called subjective, and those which are suggested by outward things are spoken of as objective. To one or other of these classes all names belong. Every fact we know either is, or is capable of being, named, *i.e.* marked out from other things for what it is itself; and when so marked, as a notion, comes within the sphere of the intellect and is capable of being reasoned upon as a logical term. Logic is the science of reasoned knowledge; knowledge registers itself in names. Sensation reaches its ultimate in them; hence they are in this regard *terms*—that is, certain given and known (real or conventional) sums of sensation collocated and combined in thought in such a way as to be separated by distinct boundaries from other collections also designated by names.

Sensation is not knowledge. Objects are presented to our senses in confused and confusing quantity. The earlier presentations of sense are obscure and vague. We require to learn to distinguish them. We feel it necessary to extricate them from the maze of multiplicity and to form them into concepts, *i.e.* bundles of sensations taken together and sheathed up, as it were, into separateness in thought and named. To accomplish this many things must be done. It is a prerequisite that each sense be healthily constituted and livingly quick, alert, and capable, so that no obstructive influence may intervene between outlying possible experiences and the inlying receptive (though not yet perceptive) mind. The mind itself must be fully ready for being brought into relation with the outward world and into exercise upon its objects. These objects, on being submitted to the mind, are examined; they are compared one with another, that their resemblances may be noted and their differences detected. This necessitates attention—fixed, careful, and thorough observation—so that the entire capacity of the mind may be concentrated on the perception of those qualities in which the sensations under its consideration coincide, and be entirely withdrawn or abstracted from engaging any of its efforts in noticing the incoincident or dissimilar qualities that may then, combined with others, be introduced to it. The resembling attributes of things, when thus discriminated and taken under view apart, are regarded as one. The mind grasps and apprehends them as a unity of sensational representations. This unity of similar and similarly related sensations it regards as an entity. All things capable of exciting those self-same sensations are held as possessing identity, and the mind separates each such separate bundle of similar sensations proceeding from objects as notions, and seals up each with a name allotted to it; so that it may always thereafter be distinguished, known, and referred to by that name-sign, and we may be saved the constantly recurring labour of resumming all the elements constituting experiences at each separate time of their reappearance.

The senses are the separate and distinct inlets to, or gateways of, knowledge. Sensations are the grouped and correlated impressions made by outward things on the perceiving mind. The senses are bodily agencies for bringing information into the mind. The body in the ordinary course of sensitive existence gives us sensations of chill or warmth, relaxation or strain, energy or fatigue, hunger and thirst, exhilaration or suffocation, pain or comfort, and many other merely organic intimations of personal percipiency, arising from nervous condition or muscular sensibility. On the outworks of our corporeal being we have cautiously laid all around the general sense of touch, as a means of knowing the qualities and learning the forms of things. The whole skin, *i.e.* the outer tegumentary surface of the body, is more or less sensitive to external impressions of *tact*. In it resides the power of exciting the mind to perceive any change wrought upon or produced in the relations of the body towards or by objects beyond itself. The mind employs it to acquire correct and express notions of temperature, hardness, softness, contour or configuration of form, size, weight, number, pleasantness or unpleasantness, &c., of the things which affect it. All the palpable properties of the objects of sense are brought into relationship with the mind by this tactile sensibility. But in the case of soluble substances, which can be evolved into any flavour, whether of fragrance or fetor, or can be made communicative of any delicacy of savour, from vapidity to sapidity, we have specific forms of tactile impressibility, and distinct organs for receiving them. The organs of taste in the mouth have, in a healthy condition, a ready susceptibility to that gustatory satisfaction which is indicated by smack or *goût*, which receives gratification from condiments, distinguishes for us the palatable from the unpalatable, and helps to guide us in our diet and drink. The integumentary membrane which lines the nostrils possesses a special aptitude for the reception of sensations derived from volatilized matter that may be of an aromatic nature, or that may be offensive by its noisomeness. By these specific forms of sensibility we are made acquainted with the qualities and properties of things that operate to produce taste and smell. The ear has the peculiar task of finding from the sounds which the percussion of bodies make, what may be learned of their nature and capacity to serve or please us. It brings to us din and resonance, cry and song, click and whisper, harshness or harmony, speech and music; and it is a great safeguard in the dark. The eye has as its proper function the perception of external things through the agency of light. Form, colour, distance, make themselves known by it; drawing, painting, and sculpture appeal to it; the external world is made peculiarly ours by its aid, and mainly by its use the thoughts of others may become known through reading, or our thoughts may be communicated to them by writing. It receives the messages of light from the furthest reaches of visual space. Aided by the microscope it introduces the mind to the knowledge of the almost infinitesimal atoms of infusorial life, and by the telescope it reveals the matchless masses which whirl throughout immensity. All these sense-perceptions—visual, auditory, olfactory, gustatory, tactile, and internal—when they have impressed the mind, elicit notions and claim names. These names logic accepts as its terms—the elements of enunciative speech. Its first duty is to examine, arrange, and classify them, and thus to resolve them into systematic (*i.e.* scientific) fitness for the use of cultured reason.

The first great division of names is that of individual and general.

Individual names are the word-signs by which the mind marks and registers single, special, and particular objects of thought, so that, in the same sense, each can be applied to only one thing and to no other. They are the same as proper names in grammar. General names are such as may be applied in the same general sense to any one of an indefinite number of individual things. Each connotes a group of qualities actually existing in similar, or nearly similar, proportions and relations in many individual phenomena. It never includes all their peculiarities, but only so many as serves to indicate their common unity as a class. Individual names are employed regarding conceptions, the whole of whose qualities and peculiarities we can realize in thought and recall in memory; but general names are used for groups of qualities differing in number, and varying to a certain extent in kind, accepted and conceived of as quite sufficient for the general purposes of thought and discourse. Considered as a unity consisting of a community of component qualities which collectively go to constitute it, a name is possessed of *comprehension* and *extension.* Comprehension refers to the number of attributes contained in the concept, and extension to the number of things which can be arranged under it. Comprehension and extension are the inverse of each other. The wider the comprehension the less the extension, the wider the extension the less the comprehension. The number of attributes conceived of as existing in *man* is much more than that included in *animal;* but under the latter a much larger number of kinds of existences is included than under the former. When comprehension is maximum, extension is minimum, and *vice versa.* The *maximum* of comprehension yields individual names; the less the extension the more general is the name.

Collective names are those which group within their signification several totals expressible separately by general names, *e.g. The present company* consists of men and women who are regarded as thinkers and workers, not drones.

Names may be classified, again, as *abstract* and *concrete.* An abstract name is the designation of the name of an attribute considered apart and by itself as an object of thought, *e.g.* swiftness; a concrete name is that of real things so far as thought is concerned. Each of these classes of names may be either general or particular; *e.g. Napoleon* and *flower* are both concrete, though the former is individual and the latter general, while *heat* is an abstract, yet general name, containing certain varieties under it, of which *blood heat* is an individual designation.

Names have still further been divided into connotative and non-connotative. Names of the former class denote (or denominate) an object, and imply the attributes of that object. Concrete general names are all connotative; but proper names though concrete are non-connotative. Names of the latter class imply an object only or an attribute only, and do not carry thought beyond that. It is desirable to free names as much as possible from indeterminate connotation, and for this purpose it is generally advisable to "define terms." The same name-sign may, when used in different relations, acquire new and, to a certain extent, different connotations. The word *man* has different connotations when used in physiology, in social economy, and in moral philosophy. Hence we require carefully to attend not to the denotation of a name only, but to its specific connotation as well.

Names are also divisible into positive, privative, and negative. This, of course, is rather a division dependent on the application or use than on the nature of a name. Positive names imply the real existence of the things of which they are the designations, *e.g.* body, mountain, &c.; privative names imply the non-existence of a quality in an object in which it ought to be found, as mindless, hopeless, and thoughtless, applied to a human being. *The blind* could only be a name of a sightless member of a seeing class. Negative names imply an opposite to a positive name; *e.g.* of the positive term *assertion*, the word *contradiction* is the negative. Similarly, the wise, the ignorant, &c.

There is yet a further division of names into two classes—relative and non-relative. In some cases a name implies in its very nature the existence of a correlative. Parent and child, master and servant, sovereign and subject; good, bad; like, unlike; sin, holiness, &c., cannot be properly understood without the one suggesting the other.

All names should be clear and distinct. When we can define with unmistakable particularity all the attributes which are comprehended under a name we are said to have a clear idea of it, and to comprehend it thoroughly; and when we are able to entertain in our minds the entire kinds or individuals which may be grouped under, and may be included in the name employed, we are regarded as having gained a distinct impression of its signification.

Names ought to be employed in a univocal, not an equivocal manner. Univocal names are such as have the selfsame signification used, *i.e.* to express precisely the same collection or group of attributes in exactly the same relations in every act of reasoning in which we are engaged, so long as that act continues to be concerned with the same subject of thought. Equivocal names are those which, having the same form and sound, are yet so used as not to express, imply, and suggest the self-same group of attributes similarly interrelated, but a different and less or more dissimilar set of qualities. In fact, a univocal name deals honestly and fairly with the word while using it, an equivocal name foists in under what seems to be the same connotation, a connotation of quite a different sort—as if, talking of the *design* of a draughtsman, we should insinuate that every *design* is a deception.

Names as signs of concepts are the materials of logic, for they represent thought. Hence logic demands that all that is really contained or implied in a concept should be completely understood in every process of reasoning; and therefore it seeks to attain a precise definition of every name, and insists on knowing every distinct subclass it is expected to include and cover. Names as terms are the instruments through which logic operates, and hence it requires that all its terms should be clearly comprehended by the mind—as a good workman desires that his tools and his materials are unimpeachably excellent for the special purpose he has in view.

DEFINITION.

That names may be dealt with in a straightforward and trustworthy manner, the logician lays it down as a right preliminary of reasonable thought and sensible discourse that the precise contents and the exact boundaries of terms should be understood and agreed upon. This is the purpose of definition. *Definition* is the setting forth in complete fulness and correct order all the elements implied in a name; although in practice men often use a synonym as if it were a definition, or satisfy themselves with some brief and pointed index to its usual or conventional meaning. A proper definition is a carefully arranged and truly correspondent statement of the various essential connotated qualities of which the name is only the sum-total. It ought to give an equivalent connotation. It presents to the mind an analysis of the whole impression contained in the mind of which the name is the synthetic representative. Logicians sometimes distinguish between the definition of a word and the definition of a thing; but in reality, when we employ "discourse of reason," words are the counters of concepts primarily, and only of things in a secondary way. We can reason as logically regarding the fairies in the "Midsummer Night's Dream" as the orbs which circle in the midnight sky, though the former airy elves are mere fancies investured in a word, and the latter whirling masses are undoubted realities, represented in the words we use to name them. The consideration of the reality of the things indicated by terms is metaphysical or scientific, not logical. Logic takes the terms as given, for what they are given, real or ideal, and, whatever the term is, requires to know its meaning—what it is to be understood as implying or connoting. The consequences which logic shows to be deducible from the terms with which it has to work are of course real only with the reality of the terms, or unreal as the terms are, and yet, so far as the reasoning is concerned, its conclusions are right and valid, if its rules have been observed. The rules for logical definition are fivefold:—

1. It must be adequate, *i.e.* the term defined ought to have

its precise and complete equivalent or counterpart in thought, and no more than that, set forth in the definition. If it is not, the definition is faulty, either in being (1) too wide, or (2) too narrow.

2. It ought to be positive, *i.e.* it should not have its connotation expressed in negatives. It should tell what a thing *is* or consists of, not what it is not and does not consist of.

3. It should be sufficient, *i.e.* no more words ought to be employed in presenting it to the mind than are absolutely required, and no omission of words actually requisite to its proper explanation ought to be allowed.

4. It ought to be precise, *i.e.* exactly and specifically correct, including everything essential and excluding everything superfluous.

5. It must be perspicuous, *i.e.* more easily intelligible than what is to be defined—proper, compendious, and clear.

The expository or explanatory analysis of the contents of a general term is sometimes so extended as to become a description. Almost all scientific definitions, in order that they may be thoroughly understood, and be really coextensive with the name employed, are at first descriptive, next declarative, and last of all definitive and symbolical, the name-sign being translated into and incorporated with the scientific and technical terminology of each science. Recognizing that fact is the ground of certainty, and that names are the means by which the connection between phenomena and phraseology is to be made manifest, if not real, logic has made an endeavour to unite the formal phrase and the substantial fact, by reducing to a minimum the method of declaring the nature of a thing; in other words, enabling men to economize the energy requisite in investigation, by abbreviating as far as possible the essential requisites of definition, and of reducing to distinctness in the mind any term which may be or seem to be indistinct, whatever be the meaning it is intended to express.

Definition, when brought to logical perfection of form, only requires to draw the line of demarcation between one class and all other classes which refer to the same idea. This will be done with logical exactness if we show how the idea (to be defined) is (1) related to others by general resemblance, which is expressed by *genus;* (2) is distinguished from them by certain peculiarities, which is expressed by *difference.* These two in union supply the idea of (3) the *species.* All the *constant* attributes and qualities come in (4) as *properties,* and all the *inconstant* ones as (5) *accidents.* Definition thus provides for the distinctness of knowledge, not for the discovery of truth. It crystallizes what we know into formal perfectness; but it does not necessarily, by any act of logical alchemy, precipitate error and leave only the true to gladden the soul. Its chief use in the culture of reason is to save us from ambiguities of expression. Every definition should be self-consistent and fixed—not so subtle as to perplex the mind, and not so far removed from popular use as to trouble it with a sense of being led astray.

CATEGORIES AND PREDICAMENTS.

The words "predicament" and "category" have fixed themselves permanently in human language as modes of methodical classification tending to orderly thought and helpful to perspicuity and brevity of speech. Categories are the original and fundamental forms of thought, according to which the mind *must* think; the word predicament signifies that they are operative within the mind prior to the formation of language at all. Every conceivable thing, according to Aristotle, must belong either to one or other of these *ten* categories—(1) Substance as an actual existence, material or immaterial; (2) quantity, in amount or number continuous or discrete, &c.; (3) quality, essential properties or powers, (*a*) innate, (*b*) acquired, (*c*) sensible; (4) relation of fitness, suitability, co-ordination, &c.; (5) action, exerting power; (6) suffering, being subject to exerted power; (7) where, position in space or place; (8) when, position in time; (9) posture, actual position; (10) possession, as (*a*) habit, (*b*) clothing, (*c*) endowment, &c., which may be had and may be lost. Sir William Hamilton rearranged these thus: (1) being or substance, (*a*) in itself, (*b*) by accident of; (2) quantity; (3) quality; or (4) relation, under which last class he includes all the other six lower categories. Archbishop Thomson arranges all things as categorically included under the heads, (1) substance; (2) attribute: this he divides into (3) quantity; (4) quality; (5) relation; and he gives the following as modes of the last: (6) time; (7) space; (8) causation; (9) composition; (10) agreement or repugnance; (11) polar opposition; (12) finite to infinite. The last three of these might, however, probably be regarded as cases of contradictory coexclusions. We annotate with figures relating to the Aristotelian categories the following lines, intended to illustrate them:—

A lady,[1] stout,[2] too[4] warmly clad,[3] at Bow,[7] one summer day,[8]
Walking[9] a mile to see[5] her son, was melted[6] quite away.[10]

Kant has arranged the categories of the understanding into the following:—

I. Quantity.	III. Relation.
(1) Unity.	(1) Substance and accident.
(2) Multitude.	(2) Cause and effect.
(3) Totality.	(3) Action and reaction.
II. Quality.	**IV. Modality.**
(1) Reality.	(1) Possibility.
(2) Negation.	(2) Existence.
(3) Limitation.	(3) Necessity.

All things that lie, or come, or can be brought within these categories can become objects of thought and may be knowable, while all that transcends these, he says, is unknowable, unthinkable by the finite understanding.

PREDICABLES.

To the categories which classify knowledge (*i.e.* thinkable things) in a scientific form there succeed the predicables, as means of arranging objects (or rather the names of objects) in a systematic scheme or order of relation. They are sometimes called "the five words," and are regarded as the several attributes which may be predicated (*i.e.* affirmed) of things. They are the results of the operations of abstraction and generalization. By abstraction, we withdraw our minds from considering any except the more essential qualities of things, and these we collect into concepts, to which we give names. By generalization, we aggregate all concepts yielding similar impressions into classes containing and connoting the same special properties. Those ideas resulting from generalization constitute *genera.* A notion which is the widest and most universal that can be thought of and entertained in the mind in regard to things is (1) a *genus, e.g.* figure, as indicating particularity of form; any concept of lower or less generality capable of being included in and thought of under (*i.e.* as forming a part of) the concept of a genus is called (2) a *species,* as *triangle,* a right-lined figure having three angles. In determining a species we require to realize in our minds as a unity all the most important qualities of a definite kind of things—those distinguishing features which fix and determine its place in the order of thought and of things; those likenesses and unlikenesses which mark it out from among other objects yielding sensations and originating ideas which enable us to conceive of them as a class. This implies that we really possess a complete knowledge of the things included by us in the class we have thus bound together in kindredness. Any quality or sum of qualities in which two (or more) related species agree with one another constitutes a genus. The *summum genus* expresses the highest generality. The categories are *summa genera.* All the species which can be co-ordinately ranged under the same genus are called con-species. As species are aggregated by a sense of likeness, they are necessarily marked off from one another by their differences. Difference is the quality or sum of qualities in which two related species (*i.e.* con-species) are unlike each other. Species unites things as being homogeneous; difference is the quality which shows them to be so far heterogeneous. Triangles are figures homogeneous in having three angles, but they are heterogeneous, and so marked off as different from each other, by being *right-*, *acute-*, or *obtuse*-angled triangles. Any single quality out of the sum (if any) of those qualities which constitute a difference; or any quality which, on knowing the difference, we

could at once infer to belong to the species characterized by it, is called a *property*. Thus, equilateral triangles are equi-angular, and equi-angular triangles are equilateral. All the other qualities or facts by which species, or any of the individuals of a species, impress us are *accidents*—are casual and unimportant in the relation in which we view them when we are reasoning regarding species. Accidents are either (1) inseparable or (2) separable; as (1) the largeness or smallness of the content of a triangle, as it must have some content, or (2) the symbol by which we indicate or imagine it when reasoning upon it, the kind of drawing in which it is presented, &c. Assertions are made and concepts are formed answering to a threefold necessity. An essential or formal necessity exists when we must think of a quality as specific or generic, as rationality is a characteristic of man; a natural necessity arises when from a difference of a thing we deduce a property —a rational man adapts means to ends; while a necessity of actuality requires us to recognize a fact as being impossible, henceforward to be disregarded in reference to a property. To be born is a property of man, the date or place of his birth is an inseparable accident. Sound is a summum genus, musical sound is a species; uniting the species with the difference tone or pitch are properties of musical sound; the notation arranges its accidents, and the mode of its audibility will show those which are separable and inseparable. Thus it seems that there are five secondary notions under one or other (or more) of which every term may be regarded in relation to each other—viz. (1) as a class consisting of higher or lower classes (genus); (2) as a class of individuals (species); (3) as a quality characterizing a class, and distinguishing it from all cognate or related classes (difference); (4) as a quality not forming the characteristic of a class, but always and peculiarly attached to one; and (5) as a quality only sometimes attached to a class.

The following rules have been laid down as governing predicables:—

1. The parts into which, as species, the whole is divided must each be separately less extensive than the divided, that is, the generic whole.
2. The parts into which the whole is divided must be, all taken together, as extensive as the divided whole.
3. The parts into which a whole is divided must be mutually exclusive one of another (*i.e.* their differences must be distinctly appreciable as opposed). This is to prevent *cross* divisions.
4. Every proper logical definition must (1) *include* (*a*) the nearest genus and (*b*) the difference, and (2) *exclude* (*a*) any property or (*b*) accident.

The main part of the foregoing instructions regarding predicables and definitions may be formulated concisely in the three following tables, viz.:—

I. Terms may be predicated of others, as

- 1. Substance.
  - 1. Genus.
  - 2. Species.
- 2. Attribute.
  - 1. Difference.
  - 2. Property.
  - 3. Accident.

II. Terms may be predicated of each other, as

- 1. The whole essence. Species.
- 2. Part of the essence.
  - 1. Material. Genus.
  - 2. Formal. Difference.
- 3. Attached to the essence or species.
  - 1. Peculiarly. Property.
  - 2. Contingently. Accident.

III. Definition is

- 1. Nominal.
  - 1. Logical, giving the meaning of the word in thought.
  - 2. Etymological, giving the meaning of the word as a term.
- 2. Real.
  - 1. Physical, assigning the actual parts, elements, &c.
  - 2. Metaphysical, assigning the logical genus and difference.

CHEMISTRY.—CHAPTER III.

MOLECULAR WEIGHTS — MOLECULAR UNIT OF WEIGHT — SPECIFIC GRAVITY OF GASES—DIVISION OF MOLECULES— ATOMS — CHEMICAL CHANGES — ANALYSIS — SYNTHESIS — COMPOUNDS—MOLECULAR WEIGHT THE MEASURE OF MATERIAL — CHEMICAL ENERGY — THE ATOMIC THEORY — CHEMICAL COMBINATION—ATOMIC WEIGHT—LAW OF DEFINITE PROPORTIONS — CHEMICAL ELEMENTS — LAW OF MULTIPLE PROPORTIONS — MULTIPLE ATOMS — HYDROGEN ATOM — TABLES OF ATOMIC WEIGHTS — ATOMIC HEAT — SPECIFIC HEAT OF ELEMENTARY BODIES.

THE molecular theory of Avogadro and Ampère being taken as the basis of the modern system of chemistry, it enables the relative weights of the molecules of all such substances as can be examined in the gaseous condition to be determined; for if equal volumes of two gases contain the same number of molecules, the relative weights of these molecules must be the same as the relative weights of the two equal volumes of gas. Now, as a cubic foot of oxygen gas weighs sixteen times as much as a cubic foot of hydrogen gas under the same conditions, each molecule of oxygen must weigh sixteen times as much as each molecule of hydrogen. In all chemical calculations the French metrical system of measurement is adopted [see NATURAL PHILOSOPHY, Chap. II.], with the addition of the *crith*, which equals very nearly 0·09 of a gramme, and is the weight *in vacuo* of one litre of hydrogen gas at 0° C. and with a tension of 76 centimetres of mercury, the normal height of the barometer. In estimating the *specific gravity* of gases this *unit* is employed. The density of a gas is therefore defined as the weight of one litre of the gas in criths, and its specific gravity as a number which indicates how many times heavier the gaseous substance is than an equal volume of hydrogen under the same conditions of temperature and pressure; and since a molecule of any gas weighs as much more than a molecule of hydrogen as a litre of the same gas weighs more than a litre of hydrogen, if the hydrogen molecule were the unit of molecular weights the number repre-

senting the specific gravity of a gas would also express the weight of its molecules in these units. For certain reasons which will presently be understood the *unit of molecular weight* is represented by the *half molecule* of hydrogen, and therefore the whole molecule of hydrogen weighs 2 units; the molecule of oxygen, which is sixteen times heavier, 16×2, or 32; the molecule of nitrogen, which is fourteen times heavier, 14×2, or 28; so that the *weight* of the molecule of any gas is expressed by a number equal to *twice its specific gravity* referred to hydrogen. The molecular weight therefore of any gas or vapour is found by doubling the specific gravity of the gaseous substance determined with reference to hydrogen gas.

So far molecules have been considered as simply differing from each other in weight, and no reference has been made to their structure. Although molecules are the limit of the physical subdivision of a substance, they are themselves capable of further subdivision, and the division of a molecule is made apparent from the phenomena which follow. Thus, taking a mass of loaf-sugar of which the weight is known, and crushing it to an impalpable powder, the microscope shows that the powder is simply made up of small pieces which are nothing but smaller lumps of sugar, each one having the same molecular properties as the larger mass. If this powdered sugar is formed into a thick syrup by dissolving it in water, and about three or four times its volume of common sulphuric acid is stirred in, the syrup becomes blackened and swells, forming a mass of loosely coherent charcoal, which rises from the liquid. This charcoal has therefore been evolved from out of the sugar, and as each molecule of sugar possessed the properties of the whole mass, each individual molecule will have contributed its share of charcoal to the mass. The charcoal, on being weighed, will be found to be considerably lighter than the original mass of sugar. Experiment shows that another substance (water) has also been evolved from the sugar, and the weight of the water added to that of the charcoal will make up the weight of the sugar. Each molecule of the sugar has therefore been divided and resolved into charcoal and water. Charcoal or carbon (see table of elements given in page 91), is a simple substance and indivisible; but the molecule of water, which weighs 18 of the hydrogen *unit of weight*, may be divided chemically into oxygen and hydrogen gas, the combined weights of which will equal that of the molecule of water, the volume of hydrogen being in the proportion of two to one of oxygen; but oxygen being sixteen times as heavy as hydrogen there will be eight times as much oxygen produced as hydrogen, or in every nine parts by weight of water there are eight parts of oxygen and one part of hydrogen; and this being so, in each molecule of water there are eight parts of oxygen to one part of hydrogen, and as one molecule of water weighs 18 hydrogen units of weight, of these 18 units $\frac{1}{9}$ or 2 units must consist of hydrogen, and $\frac{8}{9}$ or 16 units must consist of oxygen.

This division of the molecule, which is attended with the destruction of the original substance and the evolution from it of a totally different substance, enables us to classify the various changes observed in nature and to define them in terms of the molecular theory. In some changes the substance remains unaltered, though the external form may be greatly varied; such changes are termed *physical changes*. Thus a bar of iron may be converted into nails, but the material is still iron, and although the relative position of the molecules has been changed they still remain undivided. In another class of changes the substance itself is converted into new substances. Thus coal, when burnt, is converted into various gases, collectively termed in a popular way smoke; iron rusts and forms a reddish-yellow powder; sugar is converted into charcoal and water. The molecules of the original substances are disintegrated, new molecules are formed, and new substances evolved. Such changes are *chemical changes*, and when the molecules themselves are subdivided, then the substance is said to be decomposed into its constituent parts, as in the example of the sugar. When the original molecules combine with other molecules and form new molecules of greater weight, as in the case of iron and oxygen in the formation of rust, or coal with oxygen in the process of burning, then the substance is said to have *combined* with another. The decomposition of a substance into its constituent parts is termed *analysis*, and each product of the change weighs less than the original substance from which it was evolved. The combining of two substances together is termed *synthesis*, and the total product weighs more than either of the original substances alone. Thus the oxygen and hydrogen gases singly weighed less than the molecule of water from which they were evolved, and their combined weight being exactly that of the water proves that water is composed of oxygen and hydrogen gases only in the proportions evolved. The single product from the combustion of pure charcoal or carbon is *carbonic dioxide* (formerly known as carbonic acid), and weighs more than the charcoal; but the excess of weight is exactly equal to that of the oxygen consumed in the process of combustion, as may be shown by igniting a carbon filament by means of an electric current in a closed glass vessel attached to a balance (fig. 1), when no change of weight takes place, although the carbon disappears. This, therefore, shows that the molecules of the carbon have combined with

Fig. 1.

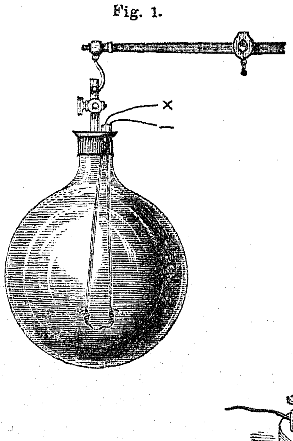
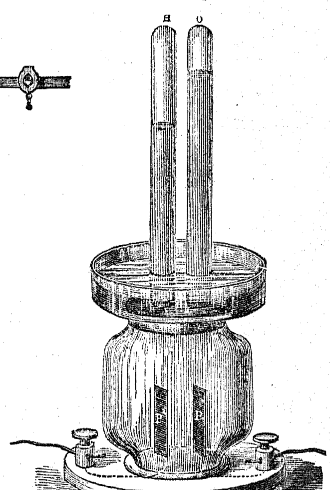
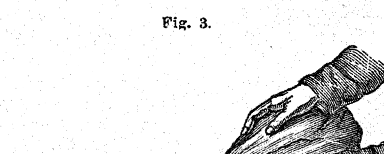


Fig. 2.



molecules of oxygen, and that the carbonic dioxide is a compound of these two substances. Thus water may be decomposed into oxygen and hydrogen gases (as shown in fig. 2) by the electric current, and the weights of the products equal exactly that of the water which has disappeared. Again, oxygen and hydrogen may be combined together, and the weight of the water formed exactly equals the weight of the two gases consumed. Molecular weight becomes therefore the measure of the material. Water yields 1800 times its volume of the two gases above mentioned. Now, the amount of energy necessary to decompose a pound of water into its constituent gases is equivalent to the raising a weight of 5,314,200 lbs. one foot high, and this enormous latent energy again becomes

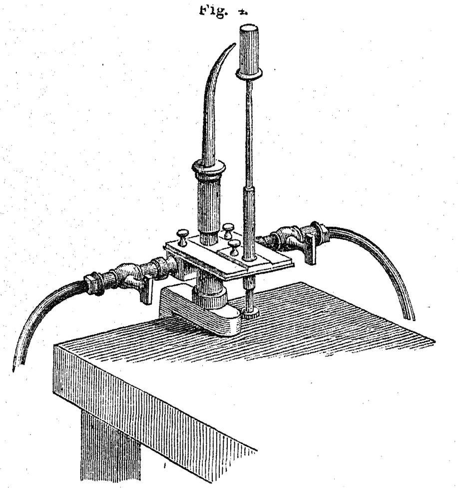
Fig. 3.



active when the gases reunite and reproduce water. Two experiments will illustrate this fact. If oxygen and hydrogen gases are mixed together in a rubber bag, in the exact proportions to form water, and a soap-bubble is blown with the mixed gases, as in fig. 3, so as to contain the same within the thin film, on inflaming the bubble a deafening explosion takes place, showing that chemical union has been completed,

and this tremendous energy has been developed in the formation of a drop of water so minute that it may be held on the point of a pin. Again, if, instead of igniting the mixture, the two gases, in proper proportions, are burnt from the jet of a compound blowpipe (fig. 4), the same development of energy takes place, the same chemical union is effected, and the

Fig. 4.



same product, water, is formed. In this instance the energy is developed under the form of intense heat, and heat is only another form of energy.

When water is decomposed the qualities of the water are entirely lost in the properties of the two gases produced from it, and a certain amount of energy is absorbed in the transformation. When the water is formed the properties of oxygen and hydrogen are entirely lost in those of the resulting liquid, and exactly the same amount of energy is set free. The change of water into the two gases, and that of the two gases into water, is attended with no loss of weight, and therefore it may be inferred that water and the gases are the same material in different forms. The only theory which so far gives an intelligible solution of the facts is the atomic theory, which assumes that hydrogen and oxygen do exist as such in water, preserving each its individuality; that each molecule of water consists of three atoms, two of hydrogen and one of oxygen; that when the water is decomposed the molecules are broken up, and that then the oxygen atoms associate themselves together to form molecules of oxygen gas, and the hydrogen atoms to form molecules of hydrogen gas; and, again, when the gases recombine, that the reverse takes place, each atom of oxygen uniting itself to two atoms of hydrogen to form a molecule of water. This theory is the *atomic theory* propounded by John Dalton, which forms so prominent a part in the modern system of chemistry. For a long time the *integrant molecules* of Avogadro and the *particles* of Ampère have been confused with the *atoms* of Dalton and the value which chemists of the old school attached to the word atom. The modern chemist assumes that the smallest particle of a chemical compound consists of a group of separate *atoms;* this group is called a *molecule,* and is assumed to be indivisible by mechanical force, but can be separated into its constituent *atoms* by chemical means.

The distinction between a *chemical compound,* in which the properties of the constituents are wholly merged in those of the resultant product, and a *mechanical mixture,* in which the qualities of each ingredient are more or less preserved, is one of great importance in chemistry. If a mixture is taken of finely divided iron (iron reduced by hydrogen) and flowers of sulphur, although the mass may be rubbed together until it is apparently homogeneous, both substances remain unchanged and their qualities wholly unaltered; but when a portion of the same mixture of iron and sulphur is formed into a small conical heap and ignited at the apex the whole mass undergoes an entire change, the sulphur and iron disappear, and a black residue takes their place—sulphide of iron. The evidence that the sulphur and the iron are still here is that the weight of the product is exactly equal to that of the sulphur and iron combined. In order to detect either the sulphur or the iron in this new substance chemical processes must be resorted to, as they cannot now be separated by mechanical means. In years gone by, before it was clearly recognized that weight is the measure of material and that no material is ever lost, it was supposed that substances underwent a transformation; and hence it was reasoned by the alchemists of old, if such and such transformations are possible, why not others? and thus many years were wasted in attempting to transform the baser metals into gold.

Chemical combination always takes place, either by weight or measure, in certain definite proportions. Thus iron and sulphur may be mixed together in any proportion, but on heating the mass combination only takes place in the proportion of fifty-six parts by weight of iron to thirty-two parts of sulphur, neither more nor less, and any excess on either side remains uncombined. Similarly, in the combination of oxygen and hydrogen, to form water eight of one and one of the other by weight are the chemical proportions, and any excess of either gas remains unchanged; and in all cases of chemical combination and decomposition definite proportions are maintained between the weights of the several constituents, which unite to form a compound or result from its decomposition. Modern chemistry assumes that all the small atoms between which the chemical union takes place have a definite weight, and are therefore definite portions of matter; and the atomic theory assumes that in the combination of sulphur and iron the two substances break up into atoms, that an atom of iron unites with an atom of sulphur to form a molecule of sulphide of iron, and that the combination takes place in the proportion by weight of fifty-six to thirty-two, which numbers represent the relative weights of the two sets of atoms, the atoms of the same substance being all similar as regards size and weight. In the case of water the atomic theory supposes, for reasons which will presently appear, that two atoms of hydrogen combine with one atom of oxygen in the proportion by weight of two to sixteen or one to eight, as before stated. This principle, first stated by Wenzel and Richter in 1777, is known in chemistry as the *law of definite proportion,* and the *atomic theory* was first applied in explanation of the law by the English chemist Dalton in 1807.

If a small quantity of finely divided iron, in which condition metallic iron burns freely in air, be ignited, a new substance is produced called oxide of iron. On weighing the product it will be found to be heavier than the original weight of iron. Material has therefore been added to it, the iron, in burning, having combined with the oxygen of the air. This experiment, one of a number, illustrates a remarkable property of iron. Hundreds of different substances may be produced from iron by various chemical processes; but in all cases, when the products are weighed, it is found that a something has been added to the iron, and nothing ever taken away from it. Chemistry cannot obtain from iron a substance weighing less than the metal used in its production; iron always remains iron.

In nature sixty-seven different substances have so far been discovered which possess this property, that no material can be extracted from them save only the original substance; in other words, these substances are incapable of decomposition, and they are therefore distinguished in chemistry as *elementary substances* (see table of elements, p. 91). All substances may therefore be resolved chemically into one or more of the sixty-seven elementary substances, and all substances themselves not elementary are formed by the union of two or more of these sixty-seven substances. Elementary substances can only combine with each other in the synthetical condition, and their union takes place in definite proportions by weight, and the proportions in which they combine are so related that numbers have been found for each element, and the elements are always found to combine to form compound bodies in the proportions by weight of these numbers or of some simple multiple of them. This addition to the law of definite proportions is termed the *law of multiple proportions.* In the table of simple elements a number has been placed against each substance. The same elementary substances frequently combine with each other in several definite proportions, and

these proportions, estimated by weight, are invariably those of these numbers or their simple multiples. For example, carbon forms two compounds with oxygen, which contain the relative number of parts by weight of each element as indicated—

Compounds.	Symbols.	Carbon, parts by Weight.	Oxygen, parts by Weight.
Carbonic Oxide, .	CO	12	16
Carbonic Dioxide, .	CO_2	12	32

The carbonic oxide is a colourless, tasteless gas, a little lighter than air. It acts as a strong poison, producing death when inhaled even in very small quantities. The fatal results from the fumes of burning charcoal or from limekilns is due to the presence of this gas. Carbonic dioxide or carbonic acid is colourless and inodorous, with a slightly acid taste; it forms the *choke-damp* of the coal mines, is given off in the process of fermentation, and occurs frequently at the bottom of old wells. It is given off in respiration and evolved in the combustion of coal gas. This gas is always found in larger quantities in dwelling-rooms than in the open air. When a room contains 0·10 per cent. of this gas the air is unfit for continued respiration.

There are five compounds of nitrogen and oxygen, whose composition, in parts, by weight is as follows:—

Compounds of Nitrogen.	Symbols.	Nitrogen, parts by Weight.	Oxygen, parts by Weight.
Nitrous Oxide, ...	N_2O	28	16 or 14 : 8
Nitric Oxide, ...	NO	14	16 " 14 : 16
Dinitric Trioxide, . . .	N_2O_3	28	48 " 14 : 24
Nitric Peroxide, ...	NO_2	14	32 " 14 : 32
Dinitric Pentoxide, . . .	N_2O_5	28	80 " 14 : 40

Fluorides of manganese are formed by compounds of manganese and fluorine by weight as follows:—

Fluorides of Manganese.	Symbols.	Manganese parts by Weight.	Fluorine, parts by Weight.
Manganous Fluoride, . .	MnF_2	55	38 $(=2\times19)$
Dimanganic Hexafluoride,	MnF_3	55	57 $(=3\times19)$
Manganic Fluoride, . . .	MnF_4	55	76 $(=4\times19)$
Dimanganic Fluoride, . .	MnF_6	55	114 $(=6\times19)$

Such examples may be multiplied without number.

Again, the two numbers, or their multiples, which express the proportions in which each of two elements combine with a third, express likewise the proportions in which they unite with each other. For instance,

32	parts of sulphur,	S,	combine with	71	parts of	chlorine, Cl.
56	" iron,	Fe,	"	71	"	" "
56	" "	"	"	32	"	sulphur, S.
14	" nitrogen,	N,	"	$3\times127=381$	"	iodine, I.
3	" hydrogen,	H,	"	381	"	" "
3	" "	"	"	14	"	nitrogen, N.

The atomic theory affords a simple explanation of the whole of these combination-phenomena. If there are as many kinds of atoms as there are elementary substances, and all the atoms of the same element have the same weight, and the *proportional numbers* express the relative weight of the different atoms, and if combination consists merely in the union between atoms, and chemical changes are determined by their aggregation, separation, or displacement, the manner in which these results are produced may be understood; for when two elementary substances combine either a single atom or some definite number of atoms of one unit with a definite number of atoms of the other, the combination must take place either in the proportion of their relative weights or in some simple multiple of that proportion, and when in any chemical change a new grouping of the atoms takes place the same relative proportions must be maintained. From what has been stated it will be seen that the molecules of every compound substance are aggregates of at least two atoms each. With elementary substances there are many whose molecules are never subdivided, the molecule and the atom then being identical, but there are several of which the molecule can be shown to consist of two or more atoms. The molecules of phosphorus probably consist of four atoms, those of oxygen, hydrogen, nitrogen, chlorine, bromine, and iodine of two atoms.

The hydrogen molecule, consisting of two atoms, will now explain why the unit of weight has been taken as the half of a hydrogen molecule or the hydrogen atom. The hydrogen atom is the smallest portion of matter that has yet been recognized in nature. As before stated, the specific gravity of a gas referred to hydrogen is the weight of the molecule as compared with the hydrogen molecule, and twice the specific gravity of a gas is therefore the weight of its molecule in hydrogen *atoms*.

The atomic weights of the molecules of the compounds of oxygen, hydrogen, carbon, and chlorine, in terms of the unit of weight, the hydrogen atom, are given in the annexed tables.

ATOMIC WEIGHT OF OXYGEN.

Compounds of Oxygen.	Weight of Molecule.	Weight of Oxygen in Molecule.
Water, ...	18	16
Carbonic Oxide, ...	28	16
Nitric Oxide, ...	30	16
Alcohol, ...	46	16
Ether, ...	74	16
Carbonic Dioxide, ...	44	32
Nitric Dioxide, ...	46	32
Sulphurous Dioxide, ...	64	32
Acetic Acid, ...	60	48
Sulphuric Trioxide, ...	80	48
Methylic Borate, ...	104	48
Ethylic Borate, ...	146	48
Ethylic Silicate, ...	208	64
Osmic Tetroxide, ...	263·2	64
Oxygen Gas, ...	32	32

Two facts in this table of atomic weights of oxygen compounds demand attention. The first is that the smallest weight of oxygen in any of the molecules is equal to sixteen hydrogen atoms; and second, that all the other weights are simple multiples of this number, and the sixteen hydrogen atoms, the smallest weight of oxygen known to exist in any molecule, must be the weight of the oxygen atom.

ATOMIC WEIGHT OF HYDROGEN.

Compounds of Hydrogen.	Weight of Molecule.	Weight of Hydrogen in Molecule.
Hydrochloric Acid, ...	36·5	1
Hydrobromic Acid, ...	81	1
Hydriodic Acid, ...	128	1
Hydrocyanic Acid, ...	27	1
Water, ...	18	2
Hydric Sulphide, ...	34	2
Hydric Selenide, ...	81·5	2
Formic Acid, ...	46	2
Ammonia Gas, ...	17	3
Hydric Phosphide, ...	34	3
Hydric Arsenide, ...	78	3
Acetic Acid, ...	60	4
Olefiant Gas, ...	28	4
Marsh Gas, ...	16	4
Alcohol, ...	46	6
Ether, ...	74	10
Hydrogen Gas, ...	2	2

Here the smallest quantity of hydrogen in any molecule weighs one atom, and the quantities of this elementary substance in the molecules of its various compounds are in every case whole multiples of the hydrogen atom, and as the molecule of hydrogen gas weighs two atoms it consists of two atoms.

ATOMIC WEIGHT OF CARBON.

Compounds of Carbon.	Weight of Molecule.	Weight of Carbon in Molecule.
Marsh Gas,	16	12
Olefiant Gas,	28	24
Propylic Alcohol,	60	36
Ether,	74	48
Amylic Alcohol,	88	60
Triethystibine,	209	72
Toluol,	98	84
Oil of Wintergreen,	152	96
Cumol,	120	108
Oil of Turpentine,	136	120
Amyl Benzol,	148	132
Dipheny Lamine,	169	144
Carbon,	12	12

This table shows a similar constancy in the multiple of twelve, and all molecules of carbon compounds whose weight is known contain either twelve hydrogen atoms of the elementary substance or some whole multiple of twelve hydrogen atoms.

ATOMIC WEIGHTS OF CHLORINE.

Compounds of Chlorine.	Weight of Molecule.	Weight of Chlorine in Molecule.
Hydrochloric Acid,	36·5	35·5
Acetylic Chloride,	78·5	35·5
Ethylic Chloride,	64·5	35·5
Phosgene Gas,	99	71
Dicarbonic Dichloride,	95	71
Chromic Oxychloride,	155·2	71
Arsenious Chloride,	181·5	106·5
Boric Chloride,	117·5	106·5
Phosphorous Chloride,	137·5	106·5
Carbonic Tetrachloride,	154	142
Dicarbonic Tetrachloride,	166	142
Silicic Chloride,	170	142
Tantalic Chloride,	359·4	177·5
Columbic Chloride,	271·4	177·5
Aluminic Chloride,	267·8	213
Dicarbonic Hexachloride,	237	213
Chlorine Gas,	71	71

The smallest weight of chlorine in a molecule is 35·5 hydrogen atoms, and this number or a multiple of it appears in all the other molecules. If, therefore, the atoms of chlorine weigh 35·5 hydrogen units, reference to the table will show that the molecule of hydrochloric acid contains one chlorine atom, the molecule of phosgene gas two atoms, the molecule of phosphorous chloride three atoms, silicic chloride four atoms, and the molecule of aluminic chloride six atoms; and as the molecule of chlorine gas is twice as heavy as the atom it consists of two atoms.

Dulong and Petit observed that when equal weights of different bodies are raised through the same number of degrees of temperature they take up different amounts of heat; that is, different bodies possess different capacities for heat, and exhibit no simple relation among themselves. For instance, the amount of heat required to raise a kilogramme of water through 100° C. is thirty-one times as large as that required to raise the same weight of platinum through the same degrees of temperature; or the same amount of heat which raises one kilogramme of water through 100° C. will raise thirty-one kilogrammes of platinum through the same temperature.

The *specific heat* of platinum is therefore $\frac{1}{31}$, or 0·032; that of water being taken as the unit. [See NATURAL PHILOSOPHY.] The specific heat of the same substance varies according as the substance is solid, liquid, or gaseous; but if, instead of equal weights, quantities be taken in the proportion of the atomic weights, the numbers expressing the capacity for heat of the atoms are very nearly equal, showing that some exceedingly intimate connection must exist between the relation of bodies to heat and their chemical nature. This is clearly shown if the specific heats of the elements are multiplied by the corresponding atomic weights. In the following table the solid and liquid elementary substances are arranged in the order of their specific heats, as determined by the French physicist Regnault; and this order will be found to be the inverse of the atomic weights:—

SPECIFIC HEAT OF ELEMENTARY BODIES.

Elements.	Specific Heat of Water=1.	Atomic Weights.	Product of Specific Heat × Atomic Weight.
Lithium,	0·9408	7·0	6·59
Sodium,	0·2934	23·0	6·75
Magnesium,	0·2499	24·0	6·00
Aluminium,	0·2143	27·5	5·89
Phosphorus,	0·1887	31·0	5·85
Sulphur (native),	0·1776	32·0	5·68
Potassium,	0·1696	39·0	6·61
Manganese,	0·1217	55·0	6·69
Iron,	0·1138	56·0	6·37
Nickel,	0·1108	58·7	6·50
Cobalt,	0·1073	58·7	6·30
Copper,	0·0951	63·5	6·04
Zinc,	0·0955	65·2	6·26
Arsenic,	0·0814	75·0	6·11
Selenium (metallic),	0·0761	79·4	6·02
Bromine (solid),	0·0843	80·0	6·75
Molybdenum (impure),	0·0722	96·0	6·93
Rhodium,	0·0580	104·4	6·07
Palladium,	0·0593	106·6	6·32
Silver,	0·0570	108·0	6·16
Cadmium (impure),	0·0567	112·0	6·35
Tin,	0·0562	118·0	6·63
Antimony,	0·0508	120·3	6·11
Iodine,	0·0541	127·0	6·87
Tellurium,	0·0474	128·0	6·06
Tungsten,	0·0334	184·0	6·15
Gold,	0·0324	197·0	6·38
Platinum,	0·0324	197·4	6·39
Iridium,	0·0326	198·0	6·45
Osmium,	0·0311	199·2	6·20
Mercury (solid),	0·0319	200·0	6·38
Thallium,	0·0335	204·0	6·84
Lead,	0·0314	207·0	6·50
Bismuth,	0·0308	210·0	6·48
Boron (crystallized),	0·2500	11·0	2·75
Carbon (diamond),	0·1469	12·0	1·76
Carbon (graphite),	0·2008	12·0	2·41
Carbon (wood charcoal),	0·2415	12·0	2·90
Silicon (crystallized),	0·1774	28·0	4·97

The specific heats of the elements are therefore very closely proportional to their atomic weights, the mean value being 6·4, which may be taken to represent the *atomic heat* of the several elements. The specific heat therefore affords a means of checking the atomic weight of a metal, or of ascertaining it in a doubtful case. In the case of the new element thallium, discovered by Crookes, at first doubts were raised whether it was to be classed with lead or the alkali metals; if with lead, its atomic weight must be 407·2; if placed with the alkali metals, its atomic weight would be $\frac{407 \cdot 2}{2} = 203 \cdot 6$. The specific heat of thallium was found to be 0·033, and when this is divided into 6·4, the common atomic heat of the metals, the number is 194, which is much nearer to 203·6

than to 407·2. The difference between 194 and 203·6 probably arises from the great difficulty of accurately determining the specific heat of bodies, and the errors arising from variations of physical condition. Carbon, boron, and silicon were formerly regarded as exceptions to the law of atomic heats, their heats being considerably below the mean of those of the other elements. Weber has, however, lately shown that the specific heats of these three bodies increase rapidly at higher temperatures, and that at particular temperatures they become constant, giving for the atomic heat a mean value of about 6·0, which is nearly the same as the other elements of small atomic weight.

	Specific Heat.	Atomic Weight.	Atomic Heat.
Silicon, ...	0·203 ...	28 ...	5·7
Carbon, ...	0·467 ...	12 ...	5·6
Boron, ...	0·5 ...	11 ...	5·5

MUSIC.—INTRODUCTION.

MUSIC AS A SOURCE OF PLEASURE AND SUBJECT OF STUDY.

"What is music?" is a question, like a good many others, much more easily asked than answered. "This," said a late eminent musician, holding up a printed sheet, "is music." To him, who had acquired the musician's faculty spoken of by Dr. Hullah, "of hearing with his eyes, and seeing with his ears," that sheet indeed was music; but to an ordinary individual it would be simply a sheet of paper dotted over with certain characters—nothing could be *heard*. "Music," says Dr. Johnson in his dictionary, "is the science of sound;" but acoustics, of which music forms an integral part, has been similarly defined. Yet it is very well known that we may have acoustical properties in perfection without having music. To most people the lexicographer's phrase would convey no real idea of the nature and character of that artistic concord of harmonious sounds with which our subject deals.

Mozart has left on record the interesting fact that his greatest and most beautiful conceptions were fully perfected in his own mind before he began to write them down, and he speaks of the thrill of pleasure which pervaded his whole being as his subject enlarged itself, became methodized and defined; so that the whole score, however long it might be, stood, like a beautiful picture or a fine statue, clearly and fully before him, and he could survey it at a glance. "All this," said Mozart, "fires my soul; the delight it gives me I cannot express." But even Mozart confessed that the actual hearing of the instruments and voices brought to him a still higher and more intense joy. Both the conception and the execution were to him music; yet it was from the actual hearing of the ear that even he derived the greatest pleasure. This was to him the outward manifestation of his inward feelings and emotions. It is, in truth, almost impossible to give in words any true conception of the nature of music, or to have, even in thought, a proper idea of its character No man born blind can possibly conceive, far less enjoy thoroughly, the beauties of earth, air, and sea, or imagine the glories of the firmament; and no words can possibly convey to him any just idea of the brilliancy of their colouring or of the grandeur and magnificence of their scenery. So, to know music we must hear it; then only can we realize its power; then only can we feel its charms.

Music differs from all the other arts in this: it cannot be seen, nor is it available to the sense of touch. It is fleeting in its nature, and, if we may so speak, spiritual in its essence. The painter hangs his picture before us; his work is finished; we have but to look upon it to perceive its merits or feel its defects. The sculptor sets up his statue; there it stands, with nothing to mar its proportions, a proof and a memorial of his skill. Even so with the architect. But the work of the musician, although finished, may never be heard otherwise than as Mozart first heard his strains, in imagination. It is the eye that other artists endeavour to gratify; it is the ear the musician requires to satisfy. The fancy, the understanding, the feelings, the emotions—these all are faculties which his art is designed to play upon and to please. Very rarely, however, can the composer be his own performer, and hence, for the accomplishment of his artistic purposes, he is dependent upon others. He must invoke the aid of his orchestra or choir, or both combined, and it is when the "stented string," as Burns calls it, is vibrating under skilful fingers, and that best of all instruments, the human voice, is pouring forth its wondrous and heart-touching tones, that we have music.

The musician has, however, this advantage over his fellow-artists—his work loses nothing through age. "Literature," as some one has said, "is the immortality of speech;" so notation, or the art of representing sounds by signs, is the means for the registration and preservation of music. The beautiful picture may become old, wrinkled, and torn; the exquisite statue may crumble into dust, and the noble building may moulder away; but music written centuries ago can thrill the heart now even as then. Are not the works of the ancient poets, philosophers, and orators still used as our models? They are embalmed in books, although even the land in which these books were written has become a wilderness. Even so the choral melodies of Gregory the Great, when heard in all their originality, simplicity, and beauty, and the more elaborate strains of the masterly Palestrina, can touch the human heart now as they did hundreds of years ago. The works of Handel were perhaps never so worthily performed as they have been within the last few years; and who can tell but that they will be even more fascinatingly interpreted many centuries hence? In the work of the true musical genius time reveals new beauties and presents fresh attractions.

Of the elements which go to make up music, and the science into which these elements have been wrought, we can, however, acquire a little more knowledge. Instead therefore of merely giving a dissertation on the music of the ancients, about which very little is really known, and that little of no great interest except to a select few, or attempting to produce a historical sketch of the rise and progress of modern music, which to a large extent must mainly be biographical, the design of these chapters will be to give practical hints and supply useful exercises to those who really wish, not only to understand musical notation, but to have the power of reading ordinary music with ease and pleasure, and to assist the student in gaining that power, scarcely less desirable, of being able to listen to music with intelligent appreciation.

In doing so, dry technical details shall as far as possible be avoided; names and signs will be introduced only when they are actually required; and exercises designed to impress upon the mind every new thing taught will be constantly supplied. Long ago the wise man said "there is nothing new under the sun." Since that time men have been constantly arranging and rearranging old ideas, so that the modern Solomon who would give to any piece of work the appearance of novelty has before him no easy task. Something, however, of freshness is here attempted in the combination of simplicity and directness—pursued with so much success by John Curwen and his followers—with the undeniable pictorial advantages of the standard notation. The one notation will illustrate and explain the other. The principle of key-relationship, so important to vocalists and instrumentalists, and of such surpassing interest to the composer, will constantly be kept in view, and no effort will be spared to make the study at once interesting, attractive, and beneficial.

CHAPTER I.

MODES OF REPRESENTING SOUNDS ON PAPER — THE STAFF AND THE TONIC SOL-FA NOTATIONS—THE TONIC CHORD.

Sounds, of whatever kind, are the result of vibrations or waves in the atmosphere (see Natural Philosophy, article "Acoustics"). To produce musical sounds, however, these vibrations must be regular and continuous, as is the case when a bow is drawn across the tightened string of a violin, or when we blow uniformly into a tube or pipe, and so set into regular vibratory motion the air which the pipe contains. Noise of any kind, such as that produced by a cart passing along the street, or that produced by the rasping of a file, &c., causes

these vibrations to reach our auditory nerves at irregular periods. In every sound of the speaking voice there is a change called an inflection, *i.e.* a constant gliding up or down. Musical sounds may vary in many particulars; the most easily observed of these is difference in height or depth, technically called *pitch*.

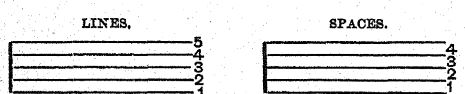
The pitch of a tone depends upon the number of atmospheric vibrations which occur in any specified unit of time, of which that tone is the result. The greater the number of vibrations the higher or shriller will the tone be, and *vice versâ*. The sounds obtained from the right-hand side of the pianoforte are said to be high, and those from the left low.

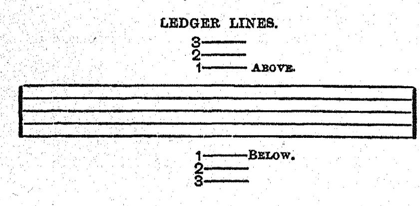
The two most prominent elements in music are *time* and *tune*. We shall take the latter of these first.

Tune consists of a succession of sounds standing, as we may say, at certain distances, in pitch, *from* each other, obeying certain laws in relation *to*, and performing certain functions *for*, each other. These sounds taken collectively are termed a *scale*. At the head of these sounds, and as it were king over them, is the key-sound or key-tone, sometimes called the *tonic*. Before we can produce anything in the nature of a tune or melody we must first have a key-tone. It is the sound from which all the others rise, the sound on which they depend as the tune proceeds, and upon which they rest when it closes. For singing purposes this key-tone is called Doh.* When we have fixed our *Doh*, which may be at any pitch suitable for our purpose, immediately the other sounds of the scale spring into existence and perform their several functions around it. Let us study these in the order of their importance.

Experience teaches us that the tone of the scale next in importance to Doh is found at the distance of what is called a *fifth* above it. The distance between, or difference in pitch between, any two sounds is called an *interval* (intervals in music are always inclusive, *i.e.* the sound with which we begin and that with which we finish are both counted). The singing name of the new sound is *Soh:* sometimes it is called the *dominant*.

Musical sounds are usually represented by characters called *notes*, which appear on a series of five parallel lines with spaces between, collectively termed the *staff*. The lines and spaces of the staff are counted upwards. Thus the lowest line is called the first line, the space between that and the line next above it is called the first space, and so on with all the other lines and spaces. Every line and every space counts one degree of the scale. Occasionally lines are required additional to those contained in the staff. These, whether added above or below, are called *ledger* lines, and their office is to supplement the ordinary staff; they and the spaces between them are always counted outwards from the staff, the first line being always next the staff, whether above or below it—





* The Sol-feggio names now so generally used in connection with the scale were first employed by a monk named Guido d'Arezzo, in the eleventh century, and were, it is said, suggested by the constant use of a Latin hymn to John the Baptist, in a verse of which these syllables begin the different lines, thus:—

Ut queant laxis *Re*sonare fibris
*Mi*ra gestorum *Fa*muli tuorum,
*So*lve pollutis *La*biis reatum,
Sancte Johannes.

For vocal purposes Ut has been changed into Doh, and Si or Te has been added in modern systems.

Another mode of representing musical sounds, and one which is being extensively used at the present time, is that known as the *Tonic Sol-fa* method. This was devised about 1840 by Miss Glover of Norwich, but greatly improved and popularized by the late Rev. John Curwen of Plaistow, who indeed made it his life work. In this method or notation the sounds are represented entirely by means of the sol-fa syllables mentioned above, and, further on, by other syllables auxiliary thereto. These syllables are first presented to the eye on a kind of musical ladder called a *modulator*, upon which the student must be so exercised that unconsciously he will have stamped upon his mind and memory a mental scale that will enable him to see the notes rising and falling, when in subsequent exercises these syllables (or their initial letters) are placed horizontally, and no rising or falling is apparent to the ordinary observer. The following illustration is the scale of C, first in the standard notation, and underneath according to the sol-fa plan. It will here be seen that the staff notation shows at a glance the height or pitch of any note as compared with those which precede or follow it, while in the tonic sol-fa notation this is only shown in the modulator, which the singer or player must ever bear in mind.

MODULATOR.

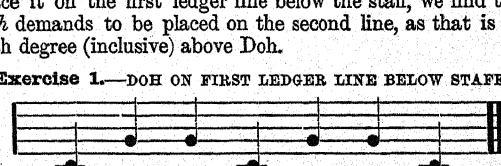
f^1
m^1
r^1
DOH^1
TE
LA
SOH
FAH
ME
RAY
DOH
t_1
l_1
s_1

d r m f s l t d^1 r^1 m^1 f^1 s^1 l^1 t^1 d^2

In singing the body should be held in an upright and easy position. Standing promotes the healthy use of all the faculties used for vocal purposes. The mouth should be freely opened, the tongue be allowed to remain flat, and the breath ought to be held back. In the earlier steps it will be a great assistance to the student if there is at hand a friend having some musical knowledge, who is gifted with a correct ear and a tuneful voice. To the beginner in any art the advantages of a good model, and of kind, sympathetic criticism, cannot be over-estimated. Failing a friend who can sing well, one who can play the pianoforte or other instrument may be called in to assist, and to make sure that the different sounds are correctly taken; but it will be well for any person who wishes to gain independent power to have recourse to instrumental aid as seldom as possible. In the belief that nearly every beginner will be able to procure assistance in one or other of these ways, signs known as clefs, flats, sharps, &c., which at this stage might be imperfectly understood, will not at present be introduced.

If we now take a certain sound called C as our Doh, and place it on the first ledger line below the staff, we find that *Soh* demands to be placed on the second line, as that is the fifth degree (inclusive) above Doh.

Exercise 1.—DOH ON FIRST LEDGER LINE BELOW STAFF.



Doh Soh Soh Doh Soh Soh Doh

There being, as already stated, a certain fixed distance between these two sounds, it follows that if we change the posi-

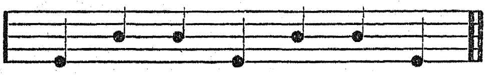
tion of Doh that of Soh must be altered accordingly. Thus if Doh is placed in the first space, Soh will appear in the third. The following is the same exercise as that given above, only higher in pitch:—

Exercise 2.—DOH ON FIRST SPACE.

d s s d s s d

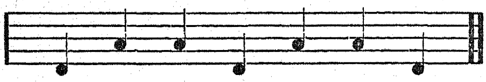
Underneath we give the same exercise, Doh in various positions, but the relation of Soh to Doh and Doh to Soh remains in each case the same:—

Exercise 3.—DOH ON FIRST LINE.



d s s d s s d

Exercise 4.—DOH ON FIRST SPACE BELOW STAFF.



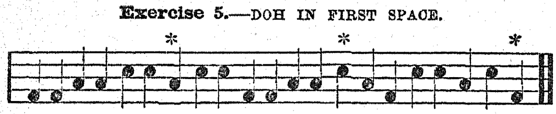
d s s d s s d

The student should now exercise himself in striking with his voice the Soh to any given Doh.

The tone of the scale which stands third in order of importance finds a place for itself almost midway between Doh and Soh. It is sometimes called the *mediant;* its singing name is Me. If Doh is placed in the first space, Me takes the second, and Soh the third. It will help the student to recognize these notes if he remembers this fact, to which Mr. Curwen first called attention—viz. that Doh, Me, and Soh are similarly placed. Thus, if Doh is in a space, Me and Soh will be in the adjacent spaces above; if Doh is on a line, Me and Soh will appear on the next higher lines.

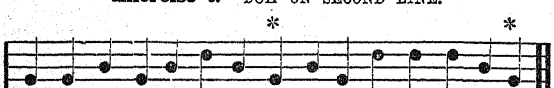
The following exercises should now be studied and practised. It will be advisable to take breath at the notes marked thus*:—

Exercise 5.—DOH IN FIRST SPACE.



d d m m s s m s s d d m m s m d s s m s d

Exercise 6.—DOH ON SECOND LINE.



d d m d m s m d m d s s s m d

Exercise 7.—DOH ON FIRST SPACE BELOW THE STAFF.

s m d m s d m m d s d m s d

Doh may in each case be taken at a different pitch, and the above exercises repeated with the new pitch chosen.

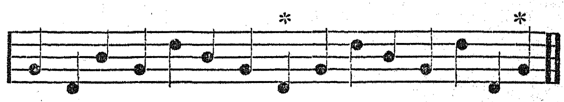
It has been found that the ordinary musical scale is limited to seven sounds, and that going higher or lower the eighth sound is so like the first that in practice it is regarded as the same. Almost the only difference between two sounds thus related is that of pitch, the eighth note above having exactly double the number of vibrations required for the production of the first. These new sounds are called the *octaves*, or eighths of those already explained. When the singing names are given, it is found useful, for distinction's sake, to mark the upper octaves with the figure 1 (or 2) above, and the lower with the figure 1 (or 2) beneath, *e.g.* $\mathbf{d^1}$, $\mathbf{m^1}$, $\mathbf{s^1}$, $\mathbf{d^2}$ for the higher octaves, $\mathbf{s_1}$, $\mathbf{m_1}$, $\mathbf{d_1}$, $\mathbf{s_2}$ for the lower.

Study in the following exercises the position and effect of upper and lower octave Doh, Soh, and Me:—

Exercise 8.—DOH ON FIRST LINE, UPPER DOH IN FOURTH SPACE.

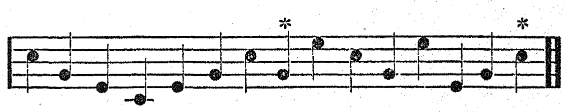
d m s d^1 s m s d m s d s m s d^1

Exercise 9.—DOH ON SECOND LINE WITH LOWER SOH.



d s_1 m d s m d s_1 d s m d s s_1 d

Exercise 10.—DOH ON FIRST LEDGER LINE BELOW, WITH UPPER DOH AND ME.



d^1 s m d m s d^1 s m^1 d^1 s m^1 m s d^1

These exercises may, as formerly, be practised with Doh taken at a different pitch.

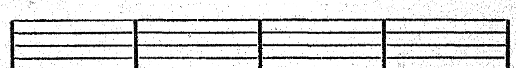
Hitherto our practical exercises have been dealing with tune, but another element, as was mentioned above, is of equal importance in music—viz. *time.* This word when used musically is not understood in its ordinary sense; it does not mean so many hours, days, or weeks, but has reference, first, to the degree of force with which different tones are struck, called *accent* or stress; second, to the relative duration of sounds, as for instance, one sound may require to be held (*i.e.* sustained in tone) longer or shorter than another—this is commonly termed *rhythm;* and third, one tune may require to be sung more quickly than another, or one person may sing any given tune slow, and another may sing it quick—this is called variously time-rate, rate of speed, rate of movement, &c. The term *time-rate* will suit our purpose sufficiently well.

Accent or stress in music, as in poetry, must come regularly. Thus if we repeat the first line of the well-known song,

"Ye banks and braes o' bonnie Doon,"

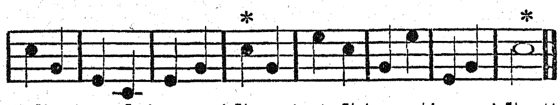
we find that the syllables are alternately soft and loud, and that the voice naturally dwells and strikes with greater force upon the words "banks," "braes," "Doon," and the first syllable of "bonnie." If now we proceed to adapt this line to music, we find that signs are required to show, first, on which notes this force or stress (accent) is to fall; second, the comparative length or duration of the different notes to each other (the rhythm); and third, the rate of speed (time-rate) at which the whole line should be sung.

Accent is shown in the ordinary notation by perpendicular lines, called *bars,* drawn through the staff, in this manner :—



The note which follows the bar is always that on which the greatest stress or accent must fall. There are no signs for the subordinate accents, but we know that accents in music come regularly, and that therefore these must occur in uniform relation to the strong accent. In the tonic sol-fa *all* the accents are shown, and each has its own particular sign. These time signs have the advantage of familiarity, being drawn for the most part from those which appear on the ordinary printed page; thus the colon (:) placed before a note shows that it bears the soft or weak accent (*i.e.* is unaccented), the long upright line placed before a note shows

as in the standard notation, that there the strong accent has to fall. Exercise 10 might be written thus:—

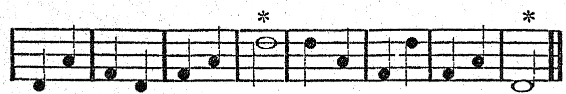


{|d':s |m :d |m :s |d' :s |m':d' |s :m' |m:s |d':- ||

Here the bars show that the accent comes on the first note, the second is unaccented, the third is accented, and so on. The two upright lines at the end, called a *double bar*, indicate that the tune or strain is finished. The distance from one accented note to the next is called a *measure.** The last note of Exercise 10 is intended to be held (*i.e.* sounded) twice as long as the others. It is therefore written oval and open in the head, and is called a *minim.* The notes used hitherto are called *crotchets.* One minim is equal to two crotchets, which is generally put in this form—one 𝅗𝅥 = ♩ ♩; in other words, if we give one beat or motion of the hand for the crotchet, the minim will require to get two. In sol-fa the dash (—) put in place of a note shows that the previous note is continued. Exercise 10 would thus have two beats in each measure.

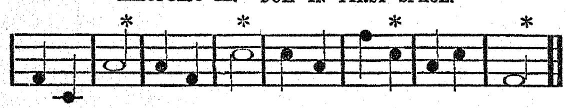
Study the following exercise and endeavour to execute it, with proper observance of tune, time (duration), and accent. Sing softly:—

Exercise 11.—DOH IN FIRST LEDGER SPACE BELOW.



{|d :s |m :d |m :s |d':— |d' :s |m:d' |m :s |d:— ||

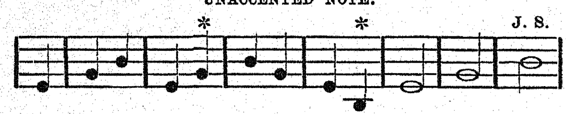
Exercise 12.—DOH IN FIRST SPACE.



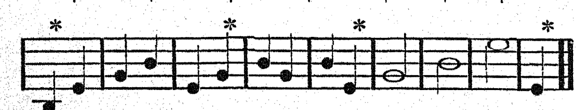
{|d :s, |m:— |m :d |s:— |s :m |d' :s |m :s |d :— ||

Exercise 13.—DOH ON FIRST LINE, BEGINS ON UNACCENTED NOTE.

J. S.



{ :d |m :s |d :m |s :m |d :s, |d :— |m:— |s :— }

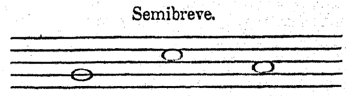


{|s, :d |m :s |d :m |s :m |s:d |m:— |s :— |d':— |d ||

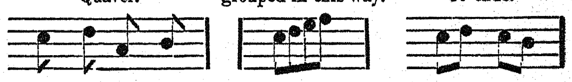
The student ought now to notice that each of these sounds produces an effect upon the mind peculiar to itself. Doh may be termed the strong tone, Soh the bright tone, and Me the calm, steady, or peaceful tone. These "mental effects" have been brought into great prominence of late years, through the writings and teaching of Mr. Curwen, though their assistance to the memory of the learner in associating sounds with syllables was long ago apparent even to Guido. "He observed," says Hawkins (vol. i. p. 157), "that in a short time the idea of association between the syllables and the notes would become so strong as to make it almost impossible to misapply them."

It very frequently happens that a note of longer duration than the minim, and another of shorter duration than the crotchet, are required. These are called respectively *semibreve* and *quaver.* In form, the semibreve is the same as the minim, but without the stem, and the quaver is the same in form as the crotchet, but with a little line or hook attached to the stem:

Semibreve.



Quaver. Sometimes, for convenience' sake, quavers are grouped in this way. Or thus.



In sol-fa, greater duration for any note is indicated by simply putting an additional dash for every new beat (generally termed a pulse) that is to be given to it. The following note would therefore get four pulses or beats, *i.e.* one for the note itself and one for every dash or horizontal line—

{|d :— |— :— ||

In singing this note the third pulse is not to be struck with so much force as the first. It is called the medium accent, and is shown by a short instead of a long upright line.

If two notes are to be sung in the time of one pulse or beat, they are called half-pulses, and the two must be written in the space allotted to that pulse, a period or dot (.) being placed exactly in the centre to show that the pulse is equally divided, thus:—

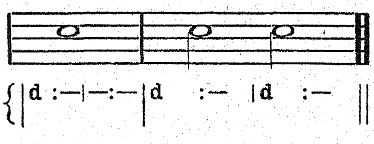
Half-pulses.

|d .d:d .d|d .d:d .d||

It is essential to notice not only the *form* of a note, but its *place* on the staff. The former indicates its duration or value, the latter its particular height or pitch.

Exercises in Time.—One semibreve is equal to two minims. In the following exercise therefore give four beats or taps of the hand to the semibreve, and two to each of the minims:—

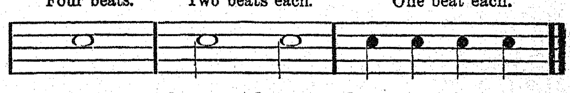
Semibreve, four beats. Minim, two beats each.



{|d :—|—:—|d :— |d :— ||

A minim is equal to two crotchets; a semibreve is therefore equal to four. Sing in time as before—

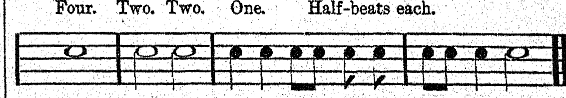
Four beats. Two beats each. One beat each.



{|d :—|—:—|d :— |d :— |d :d |d :d ||

A quaver, being only half as long as a crotchet, will get only half a beat, *i.e.* two quavers will go to a beat—

Four. Two. Two. One. Half-beats each.

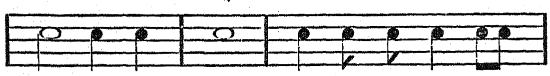


{|d:—|—:—|d:—|d:—|d :d |d.d:d.d|d.d: d |d :— ||

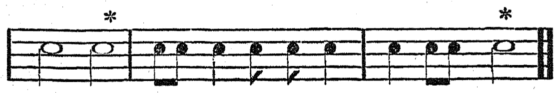
Study time alone in the following exercise:—

* The word bar is commonly used to express this sense also, as in the phrase "so many bars of music;" but as the word bar really describes only the upright lines, and not the spaces between them, we prefer to follow the example of Mr. Curwen, Dr. Stainer, and others, and call this a measure.

Exercise 14.



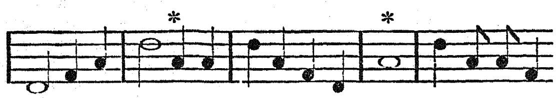
{|d :— |d :d |d:—|—:—|d :d . d|d :d . d }



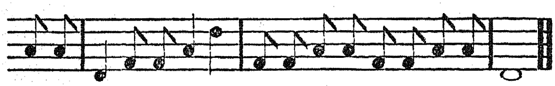
{|d:— |d:— |d . d :d |d . d :d |d :d.d|d :— ||

Study Exercise 15 first for time alone, and then for time and tune together.

Exercise 15.—FOUR BEATS IN THE MEASURE—DOH IN FIRST LEDGER SPACE BELOW.



{|d:— |m:s |d':— |s:s |d' :s |m :d |s:—|—:—|d' :s . s |m }

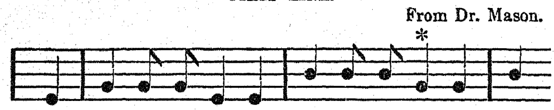


{:s . s |d :m.m|s :d' |m.m :s . s |m.m :s . s |d:—|—:—||

A dot placed after a note lengthens its duration by one-half; thus in the following the minims with the dot after them (called *dotted* minims) get three beats each:—

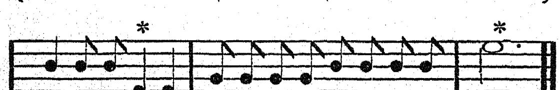
Exercise 16.—FOUR BEATS IN THE MEASURE—DOH ON FIRST LINE.

From Dr. Mason.



{ :d |m :m.m|d :d |s :s . s |m :m |s }

{:s . s |d' :d'.d' |s:— |—:s |d' :d'.d' |m :m }



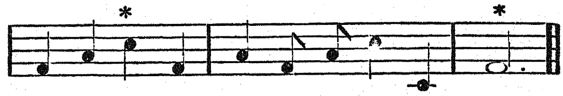
{|s :s.s|d :d |m.m :m.m |s . s :s . s |d:— |— ||

Exercise 17.—FOUR BEATS IN THE MEASURE—DOH IN FIRST SPACE.

J. S.

{:s, |d :s, . d |m :d . m |s:— |—:d |m :d . m }

{s :m . s |d':— |—:m |s :d' . s |m :s . m }



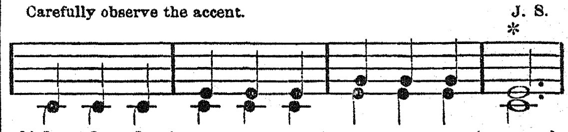
{|d :m |s :d |m :d . m |s :s, |d :— |— ||

If in any case two or more persons should be practising these exercises together, one or more of the voices may hold on or repeat Doh, the key-sound, while the other or others sing the exercise. Notice, that to Exercise 18 a second part has been added, and that these parts are intended to be sung together. When two or more parts are to be sung or played at the same time, they are either put on one staff, the stems of the notes for the upper part being turned up, those of the lower turned down (termed short score), or they are put on separate staffs, and the different staffs or parts are then bound together with a brace ({) or line. These parts taken collectively are called *a score.* Notice also, that in this exercise there are three beats (pulses) in the measure, instead of two or four, as hitherto. This kind of measure, consisting of one strong and two weak pulses or beats, is required for such lines in poetry as—

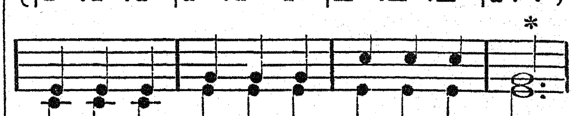
| Bird : of : the | wil : der : ness ||
| Take : her : up | ten : der : ly || &c.

Exercise 18.—THREE BEATS IN THE MEASURE—DOH ON FIRST LEDGER LINE BELOW.

Carefully observe the accent. J. S.

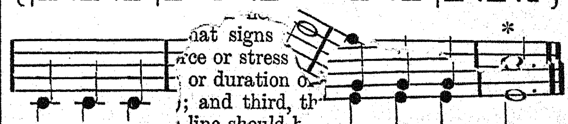


{|d :d :d |m :m :m |s :s :s |m :—:— }
{|d :d :d |d :d :d |m :m :m |d :—:— }



{|m :m :m |s :s :s |d' :d' :d' |s :—:— }
{|d :d :d |m :m :m |m :m :m |m:—:— }

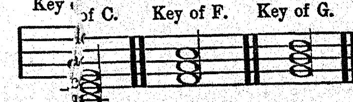
{|s :s :s |d' :d' :d' |r/:d' :s |d' :s :m }
{|m :m :m |m :d :m |\:m :m |m :m :d }



{|d :d :d | :m |s :s :s |d :—:— ||
{|d :d :d | :d |m :m :m |m:—:— ||

The sounds Doh, Soh, Me, with which our readers are now (we hope) familiar, may be sung together. When so used they form what is called the TONIC CHORD. Try the effect of the following exercise—

Key of C. Key of F. Key of G.



{|s :— ||s :— ||s :— ||
{|m :— ||m :— ||m :— ||
{|d :— ||d :— ||d :— ||

with voices or on an instrument, and in the endeavour the secret of the tonic chord will reveal itself better than any words can define it, and show it to be a combination of several sounds forming harmony.

SHORTHAND.—CHAPTER I.

SKETCH OF THE HISTORY OF ABBREVIATED WRITING—ARTIFICIAL SYSTEMS—THE ALPHABET OF NATURE—THE PRIMARY PRINCIPLES OF PHONOGRAPHY.

Shorthand possesses a history which stretches back through the ages of the past more than 2000 years. It was known to the Greeks as a method of taking notes, and of reporting speeches and addresses, by the use of abbreviations and secret signs. It was named by them σεμειογράφια and ταχυγραφια, semeiography and tachygraphy. U. F. Kopp, in his "Tachygraphia," explains and illustrates the systems of these ancient writers and reporters from specimens of Greek works written in shorthand. A knowledge of these systems was passed on to the Romans, who formed abbreviations by using the initial letters, or some of the principal letters of the words. It was, in fact, longhand shortened by using a part—sometimes only a single letter—for the whole, and by a dexterous manipulation of the orthography so as only to employ what might be called the skeletonic sketch of a word—the consonants deprived of their vowels, except in special circumstances. In many of its uses, it was a mnemonic or aid to the memory rather than a help to the setting down of one's thoughts with special speed, or an assistance in taking down from the lips of others the thoughts that breathed through them in the words which gave them utterance. It did not make sound visible and thought transferable by the signs it made. These required translation. They were generally employed to expedite transcription and to put into brief compass what needed to be readily reproduced in thought or speech; but they had no fixed principle of representation on which they proceeded. They did not consist of systematic and scientific signs so much as of suggestive ones. Hence they only secured adoption from a limited few, and were unfit for popular general use. If the ancients had had a series of simple and easily formed signs which readily entered into combination one with another as required, the monastic Scriptorium would have been the scene of less laborious trifling, and copyists would have preserved more for us of the intellectual treasures of antiquity. Of shorthand systems in the middle ages we have no notice of any importance. It is probable that some mode of abbreviating reports, notes, &c., was used; but as the memory was most diligently cultured, it is quite as likely that mnemonic systems were employed more freely and frequently than methods of shortening script. The prevalence of mnemonic forms among the scholastic logicians and grammarians seems to show that this was the case.

Shorthand is a plain English name. A great many "words of learned length and thundering sound," mostly uncouth compounds from the Greek *grapho*, I write, have been invented by various system-framers to denote it. Just as examples, we might quote semeiography, taken from Plutarch; radiography (ῥᾴδιος, ready, easy); thoögraphy (θοός, quick, nimble); tachygraphy (ταχύς, short); brachygraphy (βραχύς, short); pachybrachygraphy; polygraphy (πολυγραφία, used by Diogenes Laertius for a writing of much in little space); besides the more familiar stenography (στενός, in small compass), and phonography (φονή, sound), and charactery (χαρακτηρ, a mark). This was the name under which Dr. Timothy Bright, a learned English physician, developed a scheme of abbreviated writing upon a plan similar to the *Notæ*, or shorthand systems of the Romans. In his "Characterie, An arte of shorte, swifte, and secrete writing by character," dedicated to Queen Elizabeth (London, 1588), the ingenious author lays claim to the invention of the art. Peter Bales, who was credited by Evelyn with being the inventor, and who is named with honourable mention in Holinshed's Chronicle, was really the improver of Bright's system. In his "Brachygraphy, or the Writing Schoolmaster, in three books, teaching swift writing, true writing, and fair writing," published in 1590, he states that he was able to keep up with a moderate speaker; and we are told that he wrote a Bible in shorthand so small that it could be placed in a casket formed from an English walnut-shell. Bales, who taught writing in Oxford, improved his system and reproduced it in three parts, in 1597, as "The Art of Brachygraphy, that is, to write as fast as a man speaketh treatably; the order of Orthography; the Key of Caligraphy, that is, of fair writing. Invented by Peter Bales." In John Webster's "Devil's Law Lease" (1600), Sanittonella, in the trial scene, tells the officers of the court:—

> "You must take special care that you let in
> No Brachygraphy men to take notes."

Thomas Heywood complains regarding his "If you know not me, you know nobody" (1588):—

> "That some one by Stenography drew
> The plot, put it in print, scarce one word true."

The reference made by Heywood seems to be to the system invented by John Willis, a clergyman, who in 1602 published "The Art of Stenographie, or short-writing by Spelling Characterie." This was the earliest attempt made to introduce an alphabetical notation, and the author has the honour attributed to him of being the discoverer of the principle on which all the best modern systems of shorthand are founded. The scheme was, as might have been anticipated, crude and intricate, yet it has been the pioneer of the almost innumerable treatises which have been added to the library of shorthand up to the present time. In 1618 Edmond Willis issued his treatise on stenography. That was followed by Witt's "Stenography" (1630), and Henry Dix's "Art of Brachygraphy" (1633). A great number of other books on the subject were ushered into print in pompous phrase, and fell into speedy oblivion. The "Semigraphy, or Short-writing made plain," by Jeremiah Rich (1654), afterwards reproduced as "The Pen's Dexterity, or the art of writing Shorthand" (1659), had the honour of being practised and commended by John Locke. This system was re-issued with additions and improvements by William Addy in his "Stenographia, or the art of Short-writing" (1695), a work remarkable for the accuracy and elegance of its characters. Nathaniel Stringer also improved it somewhat, as did Samuel Botley in his "Maximum in Minimo," and many others. Mason, in 1682, issued a system which superseded Rich's work. James Weston's "Stenographie compleated, or the arte of Shorthand," in three parts, with three plates and a portrait, appeared in 1727. Mason's system was improved, matured, and modified by Joseph Gurney in his "Brachygraphy" (1751), and his descendants through a long line of official reporters—as shorthand writers to the Houses of Parliament and several governmental departments—have continued to use and improve this system. Green, Oliver, and Cooper (the author of "Parliamentary Shorthand") are improvers of Gurney's style.

Dr. John Byrom, about 1720, began to teach a system of shorthand, in which he proposed an alphabet, simple, distinct, and practical, and many amendments of details. He obtained an Act of Parliament for the security of his invention, and in 1749 issued an edition of fifty copies of his method for private circulation; but it was not till 1767, after the inventor's death, that Byrom's "Universal English Shorthand" was made public. It has been re-edited many times. To it, Thomas Molyneux of Macclesfield issued an "Introduction," and William Gawtress of Leeds also produced a much simplified and cheap adaptation of the original work.

In "An Essay intended to establish a Standard for a Universal System of Stenography or Shorthand Writing," John Taylor in 1786 made a fresh endeavour to unite brevity, simplicity, and facility. Harding, Odell, and others have explained and simplified Taylor's alphabetization. Dr. William Mavor, in 1789, added another system to the list; and this, in 1810, J. H. Clive abbreviated. An ingenious system of straight-line stenography was suggested by Richardson, and Lewis' shorthand was for a long time pushed into popularity, and its author wrote a "History of Shorthand" of some pretensions. Fancutt's "Stenography, on the Basis of Grammar" (1840), is ingenious, and might be much improved. Systems upon systems have succeeded, all implying more or less the adaptation of abbreviations to our present modes of orthography.

Having thus briefly sketched the history of literal shorthand, it is now our pleasant duty to introduce to our readers

a system which, unlike all others, has won its way to wide—we had almost said universal—adoption. This system is the invention of Mr. Isaac Pitman, of Bath, and is known as "Phonography," or writing according to sound. The first edition was published in 1837 under the title of "Stenographic Sound-hand." In January, 1840, simultaneously with the establishment of the penny post, a second edition was published under the title of "Phonography," the whole being comprised in a page of the size of letter-paper. It was engraved on a steel plate, and sold at one penny. This was only the precursor of numerous expositions of the system, the most important of which is contained in the "Manual of Phonography," a work which is now in its twelfth edition, and of which upwards of 450,000 copies have been issued. These various editions embodied many important changes and improvements, which have been introduced from time to time, as the result of numerous experiments and widely-extended experience. These alterations and improvements were at one time advanced as an argument by some persons against the adoption of phonography; but these changes were essential during the constructive period of the history of phonography, if anything approaching perfection was to be secured. Happily that period has long since passed, and its rich results are now presented.

It may be satisfactory to state that no important changes in phonography have been made during the last sixteen years, although its capabilities are being constantly developed and its application shown to almost every department of business and professional life. The "Manual of Phonography," and other works to which we shall have occasion to refer, are published by Messrs. Pitman & Sons, 1 Amen Corner, London, and the copyright of them is the property of Mr. Isaac Pitman, Bath, by whose kindness we are permitted to include in these articles the details of the system with practical directions, which will enable our readers to become personally acquainted with the art by a little careful study and some continuous practice.

Phonography, we have already said, is a system of "writing according to sound." There is nothing new in the idea of writing a language according to its pronunciation; in fact, this is the root-idea of all alphabetical writing, although it is seldom fully carried out. In phonography this is done according to the following principles:—

1. Elementary sounds in the language must be taken as the basis of the alphabet.
2. These sounds must be arranged in their natural order.
3. Every single and simple sound must be represented by a distinct sign.
4. No signs must be allowed to indicate more than one sound.

All these principles are carried out in phonography, which thus becomes a natural, a consistent alphabet of any language; and further, by the adoption of simple signs with their combinations, it is the briefest system of writing known. Before beginning the explanation of the system, it will be convenient to give our readers a glossary of the terms which we shall have occasion to use in the course of these articles. These may then be referred to as occasion requires.

Phonetics (Gr. φωνη, voice), the things relating to the voice; the science which treats of the different sounds of the human voice, and their modifications. The style of spelling in accordance with this science is named Phonetic; the common style, such as is used in this book, being called Romanic, because it is formed from an alphabet derived from that which was used by the Romans.

Phonography (Gr. φωνη, voice; and γραφη, writing), the art of representing spoken sounds by written signs; also the style of writing in accordance with this art.

Phonotypy (Gr. φωνη, voice; and τυπος, type), the art of representing sounds by printed characters or types; also the style of printing in accordance with this art.

Phonogram (Gr. γραμμα, letter), a written letter or mark, indicating a certain sound, or modification of sound; as · *ah*, ╲ *p*.

Phonotype, a printed letter, or sign, indicative of a particular sound, or modification of sound; as ɷ (in *so*, *snow*); P, p.

Logogram (Gr. λογος, word), a word-letter; a phonogram that, for the sake of brevity, represents a word; as | *t*, which represents *it*.

Grammalogue, a letter-word; a word represented by a logogram; as *it*, represented by | *t*.

Phraseogram, a combination of shorthand letters representing a phrase or sentence. [See the "Phonographic Phrase Book."]

In looking at the phonetic alphabet the first great feature that will strike the attention is its division into vowels and consonants, and the arrangement of the letters in natural order corresponding with the organs of speech employed in their formation. Vowels are simple sounds formed by the continued effusion of voice during a certain conformation of the mouth. Consonants are formed by the interruption of the effusion of vocal sound through the organs of speech touching each other. The following is the phonographic alphabet:—

THE PHONOGRAPHIC ALPHABET.

CONSONANTS.

EXPLODENTS.		Name.		Sound.	CONTINUANTS.		Name.		Sound.
P		*pee*	as in	ro*p*e.	F		*ef*	as in	sa*f*e.
B		*bee*	"	ro*b*e.	V		*vee*	"	sa*v*e.
T		*tee*	"	fa*t*e.	*TH*		*ith*	"	wrea*th*.
D		*dee*	"	fa*d*e.	TH		*thee*	"	wrea*the*.
CH	(down stroke)	*chay*	"	e*tch*.	S		*es*	"	hi*ss*.
J		*jay*	"	e*dg*e.	Z		*zee*	"	hi*s*.
K		*kay*	"	lee*k*.	SH		*ish*	"	vi*ci*ous.
G		*gay*	"	lea*g*ue.	ZH		*zhee*	"	vi*si*on.

NASALS.

M		*em*	"	see*m*.	N		*en*	"	see*n*.
					NG		*ing*	"	si*ng*.

LIQUIDS.

L	(up stroke)	*el*	"	pa*ll*.	R	(down stroke.)	*ar*	"	ai*r*.
					R	(up stroke)	*ray*	"	*r*aise.

COALESCENTS.

W	(up stroke)	*way*	"	*w*ay.	Y	(up stroke)	*yay*	"	*y*ea.

ASPIRATE.

H (down stroke) (up stroke) *aitch* as in *h*ay.

DOUBLE LETTERS.

				down		up	up
	wh,	kw,	gw,	mp,	lr,	rch,	wl,	whl.
Name.	*whay*,	*kway*,	*gway*,	*emp*,	*ler*,	*arch*,	*wel*,	*whel*.

VOWELS AND DIPHTHONGS.

SIMPLE VOWELS.

LONG. Sound as in	Sign	Sound as in	Sign	SHORT. Sound as in	Sign	Sound as in	Sign
1. AH *half*		4. AW *thought*		1. ă *that*		4. ŏ *not*	
2. EH *pay*		5. OH *so*		2. ĕ *pen*		5. ŭ *one*	
3. EE *she*		6. OO *poor*		3. ĭ *is*		6. ŏŏ *foot*	

DIPHTHONGS.

I as in *my*. OW as in *now*. OI as in *oil*. U as in *new*.

ORDER OF THE VOWELS.

The order of the simple vowels may be remembered by saying:—

Long Vowels.—Half pay she thought so poor.

Short Vowels.—That pen is not one (pronounced *wun*) foot [in length].

Other sentences in which the effect of *r* upon a preceding vowel is heard, are—

Long Vowels.—*A*unt, sp*a*re me *a*ll those sp*oo*ns.

Short Vowels.—*A*re h*e*r f*i*gs *o*r f*u*rs good?

The vowel signs are placed to a dotted shorthand letter (t) in order to show that a heavy dot represents *ah*, *eh*, or *ee*, according as it is placed at the *beginning*, in the *middle*, or at the *end* of a consonant. A short heavy dash, when written in the same places or positions, represents *aw*, *oh*, or *oo*. The corresponding short vowels are represented by the same signs made light.

Mr. Pitman, in his "Manual of Phonography," makes the following remarks upon the principles on which he has arranged this alphabet. He says,

Phonography is based upon an analysis of the English spoken language. Its consonants and vowels are arranged so as to show, as far as possible, their mutual relations. In the consonants, *p* stands first, next *b*; the rest follow in perfectly natural order, first the mute or explosive letters, proceeding from the lips to the throat; then the semi-vocals or continuants, in the same order; and lastly the nasals, liquids, coalescents, and aspirate. Scarcely more than half the consonants are *essentially different;* the articulations in the pairs *p* and *b*, *t* and *d*, *f* and *v*, &c., are the same, but the sound is, so to speak, light in the first and heavy in the second letter of each pair. The consonants in each pair are represented by strokes in the same position, and of the same shape, but that chosen for the second is written *thick*, instead of *thin;* thus, ╲ *p*, ╲ *b*, | *t*, | *d*, ╲ *f*, ╲ *v*, &c.; and thus not only is the memory not burdened with a multitude of signs, but the mind perceives that a *thin stroke* corresponds with a *light articulation*, and a *thick stroke* with a *heavy articulation.* *P*, *t*, *k*, *f*, *th*(*in*), *s*, *sh* are called light or sharp consonants, and *f*, *th*(*in*), *s*, *sh* are further denominated whispered or breathed consonants; while *b*, *d*, *g*, *v*, *th*(*en*), *z*, *zh* are heavy, flat, spoken, or murmured consonants. The difference is, that in the flat letters (*b*, *d*, *g*, &c.) a vocal murmur is added to the action of the organs by which the sharp letters (*p*, *t*, *k*, &c.) are produced. The light sounds are also called *surds*, while all the other letters (including *m*, *n*, *ng*, *l*, *r*, *w*, *y*, and the vowels) are called *sonants.* *Ch* and *j* are double consonants, formed by the union of *t*, *sh*, and *d*, *zh*, as may be heard in fe*tch*, *ch*eap; e*dg*e, *j*em. In the alphabet they are placed next to *t*, *d*, the first elements of these compound consonants. The vowels are arranged naturally in two series, palatal and labial. Each series commences with the most open sound. The *short* vowels are represented by *light* dots and strokes, and the corresponding *long* sounds by *heavy* ones. After a few weeks' practice in writing phonography the heavy strokes and dots are made without any perceptible effort; they are traced by the pen with as much facility as their corresponding heavy sounds are produced by the organs of speech.

We hope enough has been said to excite our readers' interest in this novel but natural system of writing, and to induce them persistently to go through the course of lessons we are about to outline, for their use and profit, and thus become familiar with an art of great value to all.

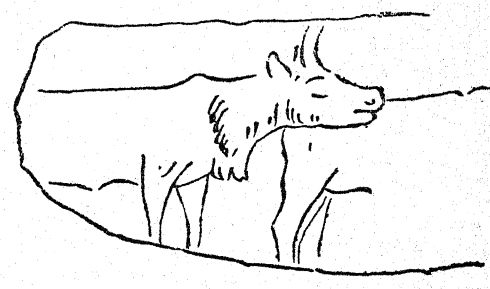
DRAWING.—INTRODUCTORY.

ART, IMITATIVE AND DECORATIVE—VARIOUS STYLES OF DRAWING—SKETCHING FROM NATURE—THE CHARM OF PEN AND PENCIL.

Drawing may be defined as the art of representing to the eye the forms of things by means of lines or shades made upon a plane or flat surface, such as a piece of paper. Yet this definition, like most others, is inadequate; for much art-work does not imitate or describe any real natural forms —it is purely decorative, that is, used for adorning, or making more beautiful, objects and spaces. Drawing may therefore be divided into two great sections, the *imitative* or realistic, and the *decorative* or ornamental, and these two divisions will include all, or nearly all, art-work.

It is impossible to say which of these methods of drawing was first practised. We know that drawings, in the way of scratchings, were made by the primitive men in the very earliest dawn of the world's history, long before written records were used, at the time when man was a barbarian—living in caves or holes in the earth—having only rough stone or carved bone weapons and tools, keeping no domestic animals, ignorant even of the arts of husbandry, spinning, and pottery. In this far-away period of savagery man made drawings. *When* he first began to exercise this craft of hand we do not know, much less do we know *why;* but we

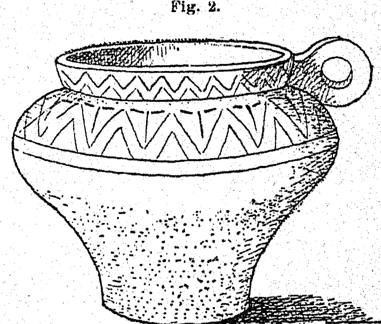
Fig. 1.



have positive evidence of the fact that he made drawings both for the purpose of description and decoration; we have actual examples of his handiwork. Buried deep in the earth, fragments of bone, ivory, slate, and other less or more imperishable materials have been found, which had upon them rude scratchings or carvings; and geologists tell us that, from the position in which these fragments were found, they must have lain there for countless ages. A specimen (fig. 1) is given above of prehistoric drawing done on a fragment of ivory by some one who had nothing but a piece of flint to work with. This drawing is descriptive, and so well does it delineate the animal that we know at once it is a reindeer. Although the lines used are few and crude, there is the right *pose* in the figure: it stands well; the prominent features of the animal's form have been seen and depicted, while the details have been almost entirely omitted.

Fig. 2 is another scratched ornament, on a piece of pottery, perhaps as early in date as fig. 1, but it is purely decorative. We cannot say that these lines imitate or describe any of the natural forms. They are done with the sole intention of making the rough earthen pot more pleasing and attractive to the eye.

Fig. 2.



The decoration takes the form of a zigzag, and it is very remarkable that in all savage nations, in all parts of the world, this zigzag ornament is in some way or other used. Such widely separated tribes as those of Scandinavia and Mexico, having probably had no communication whatever with each other, and no similarity of climate, country, or habits, still use, and use extensively, this kind of ornament.

In tracing the history of the art of drawing, we find that these two divisions, the imitative and the decorative, have always existed, and yet that they are, and must be, closely

united. The apparently meaningless lines employed can be, and have been, traced back to those of natural forms. Then these natural forms, when repeated and combined, lose their identity. They become what we call ornament, but this ornament is almost always evolved from something presented to the eye in the natural world; and, indeed, a very large amount of ornamental art is directly adapted from nature. In all the best periods of art this has been the case. Thus the Egyptians used the lotus and papyrus, common plants of their country, applying these beautiful forms to the decoration of the pillars and capitals, walls and roofs of their temples, &c.

In learning drawing, therefore, we may pursue two distinct courses, or, in other words, we have to acquire skill of two kinds—viz., the ability (1) to copy, imitate, or describe the forms of the things we see around us in the natural world; and (2) to decorate or ornament objects or spaces by means of a combination of these natural forms, or of abstract lines which we evolve from them in our imagination or combine into different arrangements in our minds. This will be found no slight study, no trivial accomplishment to be acquired in a few easy lessons. The forms which nature presents to us are innumerable, the views or appearances of these same forms are infinite, and equally infinite are their possible combinations.

Fortunately for us, we can bring *science* to help us in this great study. Our eye, our hand, our personal experience can each be aided by the acquired and stored knowledge of past generations. We can ascertain what will be the exact appearance of particular solid forms when they are presented to us in certain well-defined positions, and the exact relation which these will bear to each other when placed at various distances from us. This we can learn from the science of *perspective*. We can also study how to set down the exact dimensions of solid forms, and to repeat and combine in symmetrical harmony the abstract lines evolved from natural forms. This we are taught by the science of *geometry*.

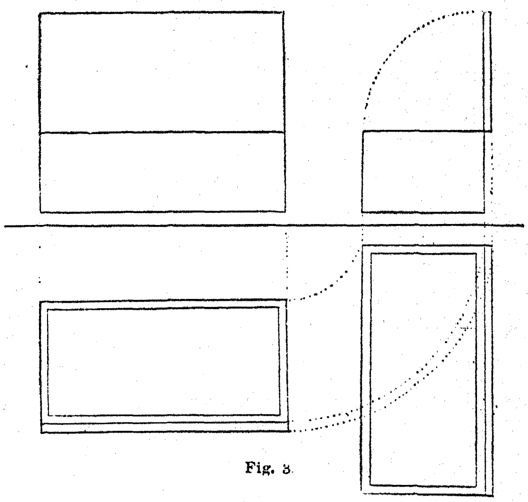
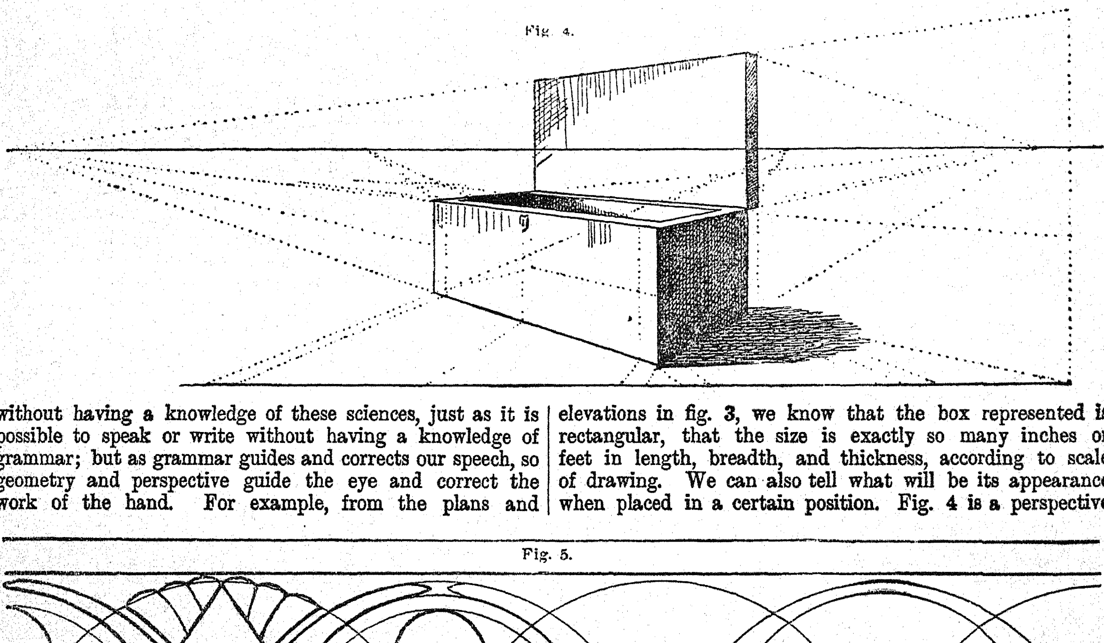


Fig. 3.

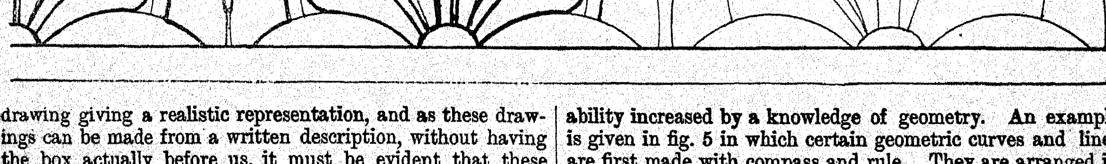
Perspective and geometry are supposed by some students to have but little connection with artistic drawing. They are, in fact, most valuable aids. True, it is possible to draw

Fig. 4.



without having a knowledge of these sciences, just as it is possible to speak or write without having a knowledge of grammar; but as grammar guides and corrects our speech, so geometry and perspective guide the eye and correct the work of the hand. For example, from the plans and elevations in fig. 3, we know that the box represented is rectangular, that the size is exactly so many inches or feet in length, breadth, and thickness, according to scale of drawing. We can also tell what will be its appearance when placed in a certain position. Fig. 4 is a perspective

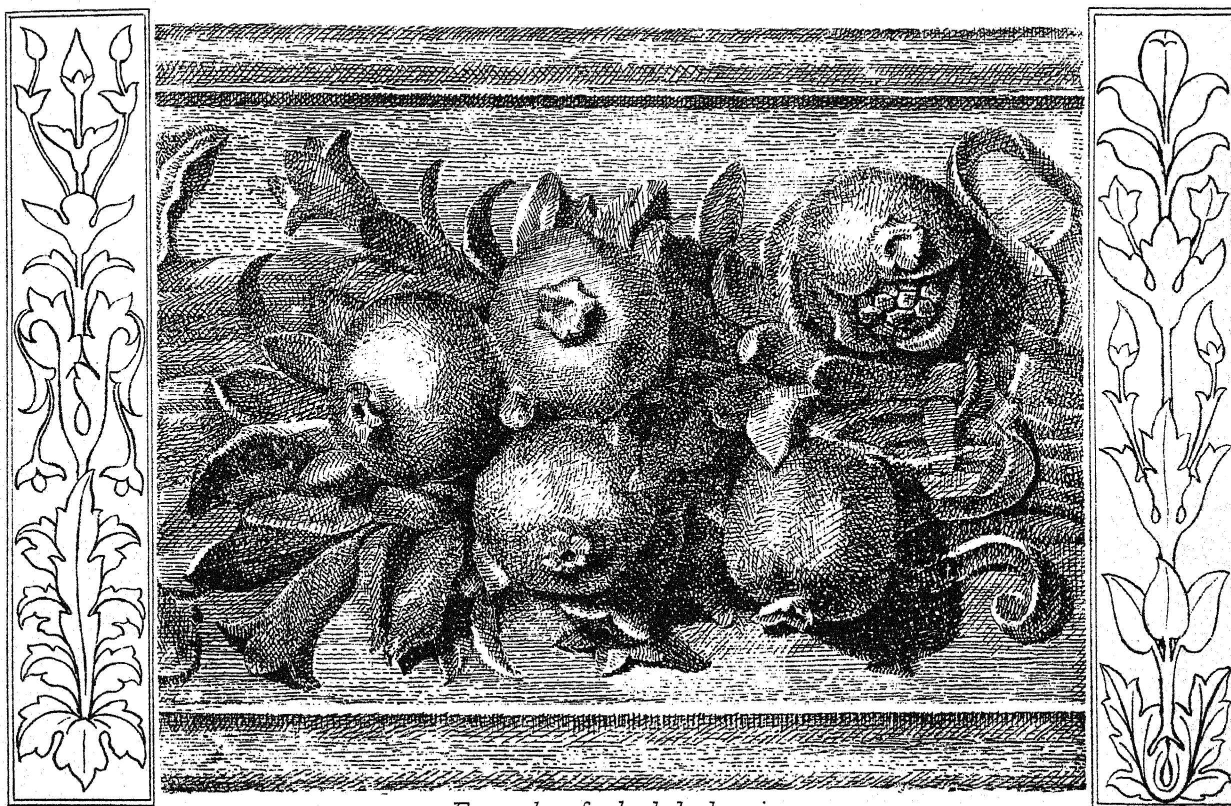
Fig. 5.



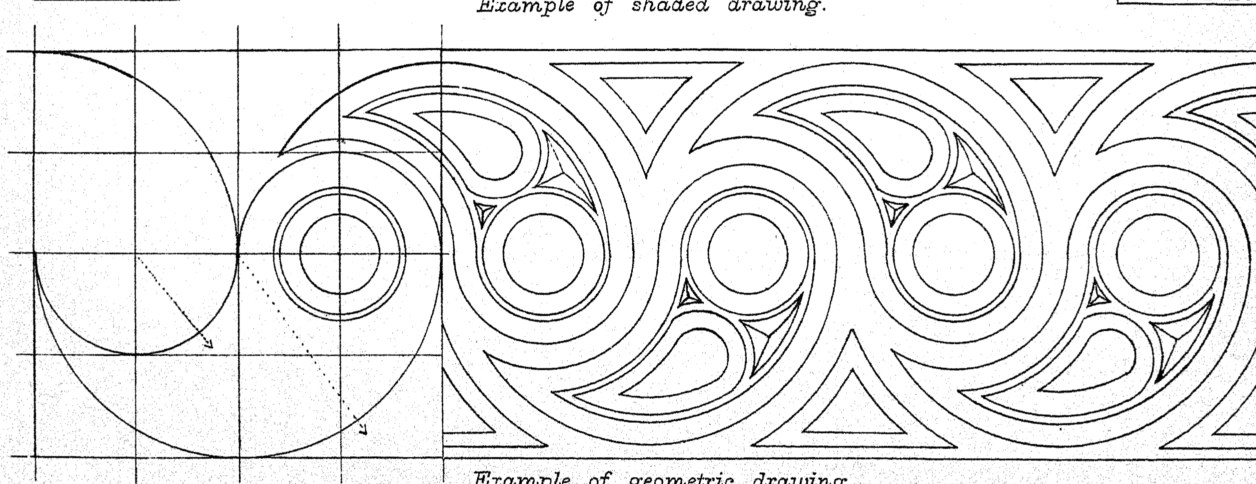
drawing giving a realistic representation, and as these drawings can be made from a written description, without having the box actually before us, it must be evident that these sciences do help us in descriptive drawing. In decoration we shall find that our hand will be aided and our artistic ability increased by a knowledge of geometry. An example is given in fig. 5 in which certain geometric curves and lines are first made with compass and rule. They are arranged in symmetrical order and repeated, and upon these lines an ornamental border is founded. These sciences are included

DRAWING.

Example of outline drawing.



Example of shaded drawing.



Example of geometric drawing.

in the schedule of the examinations of the Government Science and Art Department, in which the elementary subjects are called freehand, model, geometry, and perspective. These subjects form a fairly comprehensive course of elementary instruction in drawing, and the following series of lessons will supply special instructions in and examples of each.

While these lessons will help the student to prepare for the above-mentioned examinations, a method will be adopted which will in a great measure dispense with the usual series of drawing copies or examples used in most elementary and art schools; their place will be supplied by directions and hints which will enable the student to make or invent his own designs, thus not only exercising the hand and the eye in copying forms, but also stimulating and developing the mental faculties.

Directions will also be given which will enable the student to draw from "common objects," such as chairs, tables, stools, cups, cans, vases, and the like, in this way again bringing before him an inexhaustible series of easily attainable examples.

The art of sketching out of doors from nature will also be treated of. This, though it is one of the most difficult, is yet also, perhaps, the most charming and attractive of all the branches of drawing. No merely casual observer ever sees the face of nature as the eye of the artist sees it, or can discover and enjoy half the beauty it presents to the trained mind. The student who takes up this branch of culture should first, carefully and diligently, con the more elementary instructions, and practise, in the security and comfort of the home or the studio, the methods of drawing which will have to be used under much more trying though pleasant enough circumstances out of doors.

Great as are the difficulties of learning and teaching the art of drawing from nature, its attractions are equally great, and no earnest student of drawing in any branch can long keep himself from trying to make a "sketch" or "study" from nature. Alike by the delicately nurtured daughter of a wealthy and refined house, and by the sturdy artisan, this passion is felt. The one travels among the historic grandeur of the great countries of the world, and endeavours to put on paper or canvas the impressions she receives; the other snatches a moment from severe, it may be exhausting toil, and, by means of the railway, rushes out of the smoky town in which his work-day life is spent, for a few miles to the country, that he may catch a glimpse of nature in her own domain, and if possible, by means of brush or pencil, jot down a few memoranda of its beauties. The love of drawing from nature is alike strong in all classes; and every effort in this direction, *whatever the art result may be*, cannot but benefit both wearied body and expanding mind.

We shall therefore supply all the instruction which it is possible to give in written words on printed page, and by engraved examples, in regard to this delightful art. But we must warn the intending student that success can only be attained by constant practice, and that more than one summer's work will be necessary before the sketch or study will have much value in itself or much resemblance to nature.

In out-door sketching, in drawing natural forms and objects, and in decorative drawing various methods of working may be adopted. All geometric drawings are made by means of instruments, but it must not therefore be supposed that they are easy. There is a skilful and an unskilful way of using instruments, and skill is only acquired after much practice. When instruments are used special accuracy is expected. There must not be the slightest error, every part must be absolutely right, even to a hair's breadth.

In what is called freehand drawing, no instruments are used; the accuracy of the drawing must depend upon the eye and the hand alone. It is a common error to suppose that "freehand" means only a certain kind of outline drawing. All drawing not done with instruments is "freehand." Such drawings are sometimes shaded and sometimes done in outline only. The outline drawing must be looked upon as an imperfect or incomplete drawing; perfect representations or imitations can be made only by means of light and shade, and in some cases it is necessary to add colour.

Outline drawings are done with a lead pencil or a pen. Shaded drawings are done in many ways. The shades may be made with chalk or crayon, the hard point or the soft leather stump being used; or the shades may be done by means of a brush, using water or oil colour. The colour, or rather paint, should be what is called *monochrome*, that is, all of the same tint, the variety of shade being obtained by many *tones*. The colours generally used for this purpose are sepia, umber, or black. Beautiful shaded drawings may also be done by means of pen and ink, the varied tones being imitated by hatched or crossed lines; most of the woodcuts in these articles are done in this way.

The student must not suppose that any one method is easier or better than another: all are good. Each individual student will find that he feels strongest in some one way of working—for *him* that is the best way. Examples of outline drawing, geometric drawing, and shaded drawing are given in Plate I. The student should copy these, making the copy much larger than the example, but carefully keeping the correct proportions. The shaded drawing has been done with the pen; but it may be copied with the brush or the crayon, or with all three in succession. Drawing of any kind cannot be done without care, time, and patience. In every art difficulty is so overcome. Sir Joshua Reynolds has said that if a student would succeed in painting, or in any other art, he must go to it, willingly or unwillingly, morning, noon, and night; he will find it no play, but very hard work. Let not the student be discouraged, however; the path may be a difficult one, but interest and pleasure will be found all along the track; in this, as in all other earnestly followed worthy pursuits, he will find his chief delight not so much in the work done, or to be done, as in the doing of it.

The outline drawing at the top of Plate I. is in the style of the Renaissance, or revival of art which took place in Italy in the fifteenth and sixteenth centuries. The ornament of this period is distinguished by the careful and delicate use of foliated scroll work. The student should note in this example the character of the edges of the foliation as well as the general forms of the curves.

The shaded drawing is of the same style and period, being a copy of a portion of the bronze doors of the Baptistery of St. John at Florence. These doors were executed by Lorenzo Ghiberti, a well-known artist of the time, and they are sometimes called the Ghiberti gates; the artist worked upon them for twenty years—a wonderful example of patience as well as skill. The portion shown in the Plate is part of the frieze, or border, round the doors; the centre part is divided into panels, in which are represented scenes from Biblical history. The whole border is an excellent example of the adaptation of natural forms to decorative purposes. The doors were finished about 1420, and still remain in their original position in Florence.

The geometric drawing is a copy of a piece of Gothic tracery in Carlisle Cathedral; this tracery was extensively used in decorating the window heads, arcades, and other portions of the grand buildings of the middle ages, and during the best period (fourteenth century) was purely geometric. Very beautiful examples of the application of geometry to decorative purposes are to be found in the tracery of this period; the designs are supposed to have been made by the learned ecclesiastics of the time, the science of geometry being frequently a favourite study with them.

TRIGONOMETRY.—CHAPTER II.

As our readers must have seen, on the perusal of our first chapter, trigonometry is not exactly what, from a merely etymological point of view, it might be supposed to be from its name. It does not, for instance, include in its technical use the measurement of the *areas* of triangles. That is relegated to mensuration of surfaces. Many theorems relative to the sides and altitudes of triangles, without reference to their angles, are invariably regarded as falling to geometry, although some others may be, indifferently, included either within the limits of trigonometry or the mensuration of lines.

The trigonometrical ratios of angles are, however, not *lengths*, but *numbers*, as they are the ratios of two lengths.

Hence the numerical value of such ratios depends on the magnitude of the angle—called the angle of reference—from which the computation is made.

No other magnitude possesses such remarkable properties as the angle. It is the only magnitude which is a *function* of a number, and of which a number is a function. An angle, when given, determines ratios of lines, and so determines numbers. In this way the latter depend upon the former. Thus one angle has one ratio of arc to radius, one sine, one cosine, and all these are expressible in numbers. Between one angle, therefore, and numbers a relation may be established, while between one length and numbers there can be no regular relation fixed and known. If one length be presented there cannot be, without some other magnitude of reference, any number assigned with which that length is necessarily connected, and which is deducible immediately on that length being stated. An *arc unit* is the angle subtended by the arc which is equal to its radius. The semi-circumference of a circle contains its radius nearly 3·14159 times. A right angle therefore contains that number halved, viz. 1·57079 nearly, and from this number we can find the angles of any number of degrees, minutes, &c., and thus transform theoretical measurements into measures of *space*. It is this characteristic of an angle, therefore, which gives trigonometry its importance and its power.

Hence it is that the trigonometrical ratios of an angle are also called the trigonometrical functions of an angle. The values of the ratios of an angle cannot be computed with precise exactness, but they can be calculated so as to approximate to almost any degree of exactness. These values, in the higher parts of trigonometry, are made the subject of systematic calculation; but the values of the sines, cosines, tangents, &c., of angles have been calculated and arranged in tables of natural sines, natural cosines, natural tangents, &c., given in *logarithms*. The sines, cosines, tangents, &c., are themselves now very rarely used, as the calculation of them may be so easily managed by these logarithms.*

An explanatory word may be useful regarding trigonometrical notation. When an angle requires to be denoted by a symbol it is usual to choose either one of the English capital letters, A, B, C, D, &c., or one of the Greek cursive letters, α, β, γ, δ, θ, ϕ, &c. The small letters a, b, c, d, &c., are generally employed as the symbols of lengths. The ratio of the circumference of a circle to its diameter (which is the same as that of semi-circumference to radius) is one of the most important numbers with which the mathematician requires to deal. It is always denoted by the Greek letter π. The calculation is that the circumference divided by the diameter is equal π, where π represents nearly $\frac{22}{7}$, more nearly still $\frac{355}{113}$, or—the decimal right to five places—3·14159, as given above.

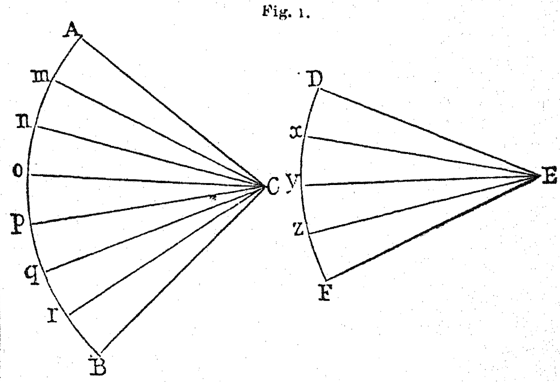
The foundations of plane trigonometry have already been shown to be laid in geometry. The fact that any angles at the centre of a circle have the same proportion to one another as the arcs of the circle intercepted between the lines which contain the angles, lies at the basis of trigonometrical science. This is a matter of such primary importance that, though it is customarily accepted because it has been demonstrated in geometrical treatises, we may perhaps, to keep our footing firm as we proceed, take a little trouble to make sure of it. Let us lay it before ourselves as a theorem—a subject not only to be looked at, but to be looked into, so that we may see the principle which underlies the apparent fact.

THEOREM. *In the same circle (or in equal circles) any angles formed at the centre are proportionate to each other as the arcs of the circle (or equal circles) intercepted between the lines which contain the angles.*

Consideration of this theorem will fall into two parts—(1) when the arcs are commensurate; (2) when the arcs are incommensurable.

1. Let the arcs A B, D F (fig. 1) have a common measure, Am, and suppose the arc Am to be contained seven times in arc

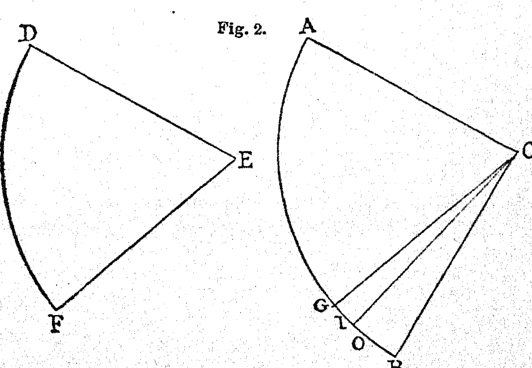
Fig. 1.



A B, viz. Am, mn, no, op, pq, &c., and four times in the arc D F, then the arc D F shall contain four equal parts, Dx, xy, yz, zF, of which each is equal to any one of the seven equal parts into which the arc A B is able to be divided. Draw straight lines from the centres of the circles to the points of proportional division. These lines will divide A C B into seven angles and D E F into four angles, which are all equal one to another (Euclid iii. 27). Therefore the whole angle A C B has to the whole angle D E F the proportion of the number 7 to the number 4, and this proportion is the same as that of the arc A B to the arc D F, while the parts of these arcs, Am, mn, &c., and Dx, xy, &c., are intercepted between the lines which contain the angles ACm, DEx, &c., respectively.

2. Let next the arcs A B, D F be incommensurable, *i.e.* have no common measure (fig. 2), the angles A C B, D E F

Fig. 2.



will still be to each other as the arcs A B and D F. Suppose D F to be the less arc, and in A B, the greater, let A G be taken equal to D F and join C G; then, if the angle A C B be not proportioned to the angle A C G as the arc A B is to the arc A G, these angles will be to each other as A B is to an arc greater or less than A G. Suppose this arc to be A O, an arc greater than A G, we shall then have the angle A C B proportioned to the angle A C G as the arc A B is to the arc A O. If, now, A B is conceived to be divided into a number of equal parts, each of which shall be less than G O, then one at least of the points of division will fall between G and O. Let I be

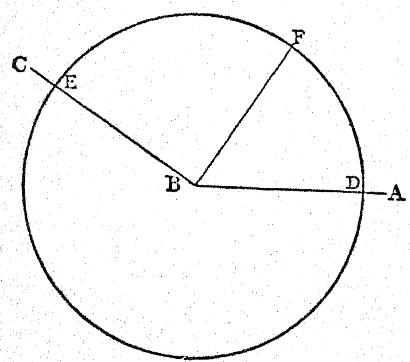
* Regarding these tables, it is well to observe that sines and cosines of arcs, and the tangents of arcs less than 45 degrees, being less than 1 (the unit of linear measure being the radius), have their logarithms negative. The working of these would be extremely inconvenient, and to overcome this the logarithms of the tables are made greater by 10 than the real logarithms of the numbers. This it is necessary to keep in mind always when using such tables. For example, using 1 for the true logarithm and L for the table logarithm, the tangent $A = \frac{\sin A}{\cos A}$, therefore $\tan A = 1 . \sin A - 1 . \cos A$, therefore $L . \tan A - 10 = L \sin A - 10 - \cos A + 10$, or $\tan A = L \sin A - L \cos A + 10$. In the tables, too, the natural sines, &c., are usually given to radius 10,000, but by the removal of the decimal point four places to the left they are adapted to radius r.

that point and join C I, then the arcs A B, A I will be to each other as two whole numbers, and (by part 1) the angle A C I to the angle A C B as is the arc A I to the arc A B. Therefore the angle A C I is to the angle A C G as is the arc A I to the arc A O. But the arc A O is greater than the arc A I, therefore the angle A C G must be greater than the angle A C I; but it is less than it, and therefore it is impossible that the arc A O can be greater than A G. Pursuing similar reasoning, it will be seen that the angle A C B cannot have the same proportions to the angle A C G as the arc A B to an arc less than A G, consequently the required arc, being neither greater nor less than A G, must be equal to it. Therefore the angle A C B is to the angle A C G as is the arc A B to the arc A G. Similar reasoning will prove that in equal circles any two sectors A C B, D E F are to each other as the arcs A B and D F.

This is the trigonometrist's ground for accepting it as manifest that an angle at the centre of a circle has the same ratio to four right angles as the arc on which it stands to the entire circumference of the circle. He finds that it is a fact that angles may be measured and compared with each other by means of arcs of circles described, with the angular points as the centre, with equal *radii.* It follows hence that angles and arcs of circles may be used as measures of each other, when the arc is less than the semi-circumference. On the same grounds we get out of the difficulty at once in geometry, in language, and in logic, that we cannot with propriety speak of an angle that is greater than two right angles. But as an arc may be imagined that can exceed not only a semi-circumference, but even a circumference, or any number of circumferences, we get a unit of angular measurement free from ambiguity.

We have a unit of angular magnitude called a degree, and the conception of the size of an angle may be best obtained by regarding it in relation to that fixed magnitude; and we can thereafter translate the measure of an angle into the measure of its arc. Let us take any angle, as A B C (fig. 3);

Fig. 3.



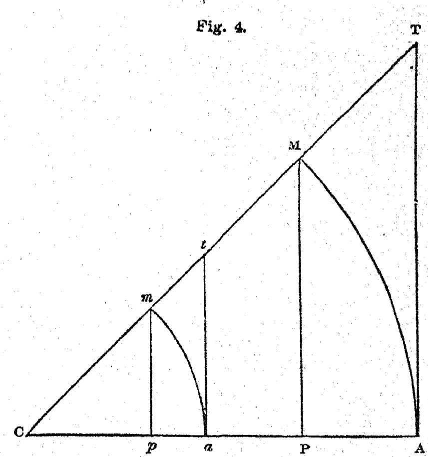
and, with B as centre, taking any suitable radius, describe a circle cutting A B in D and B C in E. Now let us, at A B F, make an angle equal to the unit of circular measure (*i.e.* $\frac{2 \text{ right angles}}{\pi} = \frac{180°}{3{\cdot}14159} = 57°{\cdot}29577$, which call—roundly for working purposes—57°·2958); then the arc D F equals the radius B F. Now, by the theorem just solved, the angles D B F and F B E are proportioned to their arcs D F, F E, and the whole angle D B E to the whole arc D E. From this we see that the circular measure of an arc is equal to a fraction, of which the numerator is the arc subtended by that angle at the centre of any circle, and its denominator the radius of that circle $= \frac{\text{radius}}{\text{arc}}$.

We may now undertake to consider the following theorem, which we may call

PROPOSITION I. *The sine, tangent, &c., of an arc which is the measure of any given angle, bear the same proportion to the sine, tangent, &c., of any other arc which is the measure of the same angle as the radius of the first arc bears to the radius of the second.*

Let M P be the sine, A T the tangent, C T the secant, and A P the versed sine [see for the definitions of these terms pp. 95, 96] of the arc A M to the radius C A (fig. 4): and let *mp*, *at*, C*t*, and *ap* be the sine, tangent, secant, and versed sine

Fig. 4.



to the radius C*a*. Then (from similar triangles) M P would bear the same proportion to *mp* as C M to C*m*; and also because C P is proportional to C*p*, as C M is to C*m*, the ratio between C A and C*a* is similar. Hence also A P is to *ap* as C A is to C*a*. The others may all be proved in the same manner. This demonstration distinctly proves that trigonometrical lines bear a constant proportion to their respective radii; and as this is the case, we are able to regard it as enough in the case of each angle to determine its relation to its own particular radius. If, for example, we call any radius R, we shall have the following results:—

$$\sin 0 = 0, \ \tan 0 = 0, \ \sec 0 = R$$
$$\cos 0 = \sin, \ 90° = R$$
$$\cot 0 = \tan, \ 90° = \infty$$
$$\operatorname{cosec} 0 = \sec, \ 90° = \infty$$

The symbol ∞ here used denotes any number which is infinitely great, as the symbol 0 denotes a number infinitely small. When we see, for example, $\frac{R}{0} = \infty$, it means that if any finite number represented by R is divided by a number infinitely small [0], the result will be a number infinitely great [∞].

There are, as we have seen, three trigonometrical lines for each angle, viz., sine, tangent, and secant. The three similar lines in any complementary triangle are called cosine, cotangent, and cosecant. Angles which are complementary one of another have their sines, cosines, tangents, cotangents, secants, and cosecants reciprocally equal, *i.e.* the cosine of an angle is equal to the sine of the complement of the angle, and the sine of an angle is equal to the cosine of the complement of the angle. The same relation holds good of the others.

RELATIONS OF TRIGONOMETRICAL LINES.

In the succeeding paragraphs we shall use the abbreviations Sin, Cos, Tan, Cot, Sec, Cosec, Vers, to denote the sine cosine, &c., to the radius r; and sin, cos, &c., to denote them supposing the radius = 1.

(1) If C K L be drawn perpendicular to A B (fig. 5), A K = K B, the angle A C K = B C K, and the arc A L = B L, therefore A B = 2 . A K. But A K is evidently the sine of A L or $\frac{1}{2}$ A B, and the straight line A B is the chord of the arc A B; hence Chord A B = 2 . Sin $\frac{A B}{2}$, and chord A B = 2 sin $\frac{A B}{2}$.

(2) A D = A C − C D, or Vers A B = r − Cos A B, and therefore vers A B = 1 − cos A B. By the convention established with regard to signs it will be found that this equation applies to arcs terminated in all quadrants of the circle.

By similar triangles, $AE = \frac{DB \times CA}{CD}$, or $\text{Tan}\ AB = \frac{r.\,\text{Sin}\ AB}{\text{Cos}\ AB}$, and $\tan AB = \frac{\sin AB}{\cos AB}$.

By similar triangles, $FG = \frac{CD \times CF}{DB}$, or $\text{Cot}\ AB = \frac{r.\,\text{Cos}\ AB}{\text{Sin}\ AB}$, and $\cot AB = \frac{\cos AB}{\sin AB}$.

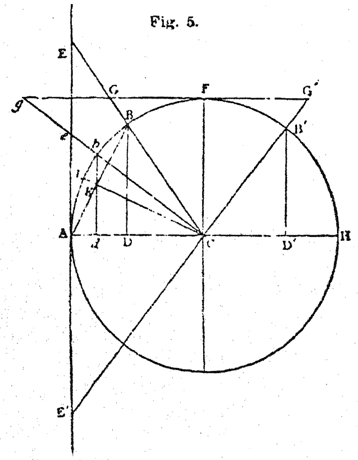
Multiplying together these expressions, $\text{Tan}\ AB \times \text{Cot}\ AB = r^2$, and $\tan AB \,.\, \cot AB = 1$.

By similar triangles, $CE = \frac{CA \times CB}{CD}$, or $\text{Sec}\ AB = \frac{r^2}{\text{Cos}\ AB}$, and $\sec AB = \frac{1}{\cos AB}$.

By similar triangles, $CG = \frac{CF \times CB}{DB}$, or $\text{Cosec}\ AB = \frac{r^2}{\text{Sin}\ AB}$, and $\text{cosec}\ AB = \frac{1}{\sin AB}$.

(3) Suppose $HB' = AB$; then AB' or $180° - HB'$ is the supplement of AB; and $B'D' = BD$, $CD' = CD$, $AE' = AE$,

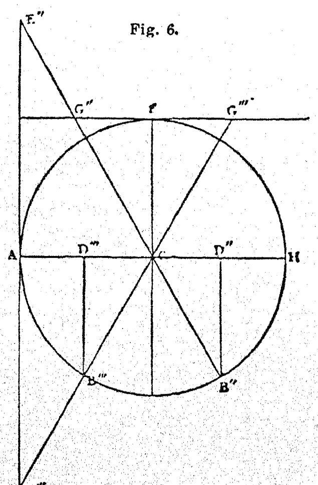
Fig. 5.



$CE' = CE$, $FG' = FG$, $CG' = CG$, $AD = HD'$. Hence the sine and cosecant of any arc are the same as those of its supplement; the cosine, tangent, cotangent, and secant are equal in magnitude, with different signs; and the versed sine of one is the suversed sine of the other.

(4) If $Ab = FB$, and bd, Ceg be drawn as before, it is plain that $bd = CD$, $Cd = BD$, $Ae = FG$, $Fg = AE$, $Ce = CG$, $Cg = CE$. But bd, Cd, Ae, Fg, Ce, Cg are the sine, cosine,

Fig. 6.



tangent, cotangent, secant, and cosecant of Ab or BF, and BF is the complement of AB; hence the sine, cosine, tangent, cotangent, secant, and cosecant of the complement of an arc are respectively equal to the cosine, sine, cotangent, tangent, cosecant, and secant of the arc.

All these theorems have been proved for arcs less than a quadrant. If, however, we make use of the convention established with regard to signs, it will be found that they apply to every case. For example, when the arc, as $AFHB'''$ (fig. 6), is greater than three quadrants and less than four, the sine is negative, the cosine is positive; therefore the tangent $= \frac{\text{sine}}{\text{cosine}}$ ought by the formula to be negative, which, from the figure, it appears to be. The magnitude is determined by the same proportion as before, and cannot be erroneous. The secant $= \frac{1}{\text{cosine}}$ ought to be positive, and the cosecant $= \frac{1}{\text{sine}}$ ought to be negative, as they are found to be. The same, it will be found, is true for every other case.

By similar triangles the following proportions will easily be verified. Radius : Sin AB :: Sec AB : Tan AB; therefore $\text{Sin}\ AB = \frac{r.\,\text{Tan}\ AB}{\text{Sec}\ AB}$, and $\sin AB = \frac{\tan AB}{\sec AB}$.

Radius : Cos AB : : Cosec AB : Cot AB; therefore $\text{Cos}\ AB = \frac{r.\,\text{Cot}\ AB}{\text{Cosec}\ AB}$, and $\cos AB = \frac{\cot AB}{\text{cosec}\ AB}$.

Since, in accordance with the celebrated theorem of Pythagoras, commonly known as Proposition 47, Euclid, Book I., which shows that "in every right-angled triangle the square of the hypotenuse is equal to the sum of the squares of the other two sides," we know that $(\text{Sec}\ AB)^2 = r^2 + (\text{Tan}\ AB)^2$, or $\sec^2 AB = 1 + \tan^2 AB$, and $\text{cosec}^2 AB = 1 + \cot^2 AB$, we may thus express these values:

$$\sin AB = \frac{\tan AB}{\sqrt{1+\tan^2 AB}} = \frac{\sqrt{\sec^2 AB - 1}}{\sec AB};$$

$$\cos AB = \frac{\cot AB}{\sqrt{1+\cot^2 AB}} = \frac{\sqrt{\text{cosec}^2 AB - 1}}{\text{cosec}\ AB}.$$

And these equations may be thus expressed:

$$\cos AB = \frac{1}{\sqrt{1+\tan^2 AB}};\quad \sin AB = \frac{1}{\sqrt{1+\cot^2 AB}}.$$

In the same way, observing that $\sin^2 AB + \cos^2 AB = 1$, we find $\tan AB = \frac{\sin AB}{\sqrt{1-\sin^2 AB}} = \frac{\sqrt{1-\cos^2 AB}}{\cos AB}$;

and that $\cot AB = \frac{\cos AB}{\sqrt{1-\cos^2 AB}} = \frac{\sqrt{1-\sin^2 AB}}{\sin AB}$.

These are the principal formulæ of the relations of trigonometrical lines belonging to one arc.

Using x as the representative of a positive arc less than a quadrant, the following express the relations of the trigonometrical lines algebraically, viz.—

1.	$\sin^2 x + \cos^2 x = 1$	7.	$\text{cosec}\ x = \frac{1}{\sin x}$
2.	$1 + \tan^2 x = \sec^2 x$	8.	$\tan x \cot x = 1$
3.	$1 + \cot^2 x = \text{cosec}^2 x$	9.	$\sin x = \frac{1}{\text{cosec}\ x}$
4.	$\tan x = \frac{\sin x}{\cos x}$	10.	$\cos x = \frac{1}{\sec x}$
5.	$\sec x = \frac{1}{\cos x}$	11.	$\text{vers}\ x = 1 - \cos x$
6.	$\cot x = \frac{\cos x}{\sin x} = \frac{1}{\tan x}$	12.	$\text{covers}\ x = 1 - \sin x$

The following algebraical expressions of the conventional circular functions of the trigonometrical lines may be found useful for reference; the four quadrants are represented by the figures (1), (2), &c., and x represents the arc or angle:—

(1) $\sin(\pi - x) = +\sin x$	(3) $\sin(2\pi - x) = -\sin x$
$\tan(\pi - x) = -\tan x$	$\tan(2\pi - x) = -\tan x$
$\sec(\pi - x) = -\sec x$	$\sec(2\pi - x) = +\sec x$
$\cos(\pi - x) = -\cos x$	$\cos(2\pi - x) = +\cos x$
$\cot(\pi - x) = -\cot x$	$\cot(2\pi - x) = -\cot x$
$\operatorname{cosec}(\pi - x) = +\operatorname{cosec} x$	$\operatorname{cosec}(2\pi - x) = -\operatorname{cosec} x$
(2) $\sin(\pi + x) = -\sin x$	(4) $\sin(-x) = -\sin x$
$\tan(\pi + x) = +\tan x$	$\tan(-x) = -\tan x$
$\sec(\pi + x) = -\sec x$	$\sec(-x) = +\sec x$
$\cos(\pi + x) = -\cos x$	$\cos(-x) = +\cos x$
$\cot(\pi + x) = +\cot x$	$\cot(-x) = -\cot x$
$\operatorname{cosec}(\pi + x) = -\operatorname{cosec} x$	$\operatorname{cosec}(-x) = -\operatorname{cosec} x$

The sine and the cosine may have any value between -1 and $+1$; the tangent and the cotangent any value between $-\infty$ and $+\infty$; the secant and the cosecant any value between $-\infty$ and -1, and between $+1$ and $+\infty$; the versed sign is always positive, and may have any value between 0 and 2. No trigonometrical ratio changes its sign *except* when it passes through the value zero 0, or the value infinity, ∞.

The following facts and formulæ, constantly recurring in trigonometrical calculations, may be committed to memory:—

The unit of linear measure is the *radius.*

π symbolizes ratio of circumference to diameter, or of semicircumference to radius.

$\pi = 3{\cdot}14159 = 3\frac{1}{7}$ or $\frac{355}{113}$, nearly.

Circumference of circle $= 2\pi r$, area $= \pi r^2$.

ω symbolizes radius.

$$\omega = \frac{180}{\pi} = 57{\cdot}29577;\ \omega^\circ \text{ (of arc)} = \textit{radius.}$$

ω° (of angle) $=$ *unit of circular measure.*

The unit of circular measure is *the angle which, in any circle, subtends at the centre an arc equal in length to the radius.*

$\tan = \dfrac{\sin}{\cos}$	$\sin^2 + \cos^2 = 1$	$\sin 30^\circ = \frac{1}{2}$
	$\sec^2 - \tan^2 = 1$	$\sin 60^\circ = \frac{1}{2}\sqrt{3}$
$\cot = \dfrac{\cos}{\sin}$	$\operatorname{cosec}^2 - \cot^2 = 1$	$\sin 45^\circ = \frac{1}{2}\sqrt{2}$

The *sequence* of algebraic signs in the four quadrants is

for *sine* and *cosecant* $(+ + - -)$,
for *cosine* and *secant* $(+ - - +)$,
for *tangent* and *cotangent* $(+ - + -)$.

$$\sin A = +\sin(180^\circ - A) = -\sin(180^\circ + A) = -\sin(-A)$$
$$\operatorname{cosec} A = +\operatorname{cosec}(180^\circ - A) = -\operatorname{cosec}(180^\circ + A) = -\operatorname{cosec}(-A)$$
$$\cos A = -\cos(180^\circ - A) = -\cos(180^\circ + A) = +\cos(-A)$$
$$\sec A = -\sec(180^\circ - A) = -\sec(180^\circ + A) = +\sec(-A)$$
$$\tan A = -\tan(180^\circ - A) = +\tan(180^\circ + A) = -\tan(-A)$$
$$\cot A = -\cot(180^\circ - A) = +\cot(180^\circ + A) = -\cot(-A)$$

$\left.\begin{array}{l}\sin \,\&\, \operatorname{cosec}\\ \cos \,\&\, \sec\\ \tan \,\&\, \cot\end{array}\right\}$ are reciprocals, and have the same conventional sign.

$$\sin(A \pm B) = \sin A \cdot \cos B \pm \cos A \cdot \sin B$$
$$\cos(A \pm B) = \cos A \cdot \cos B \pm \sin A \cdot \sin B$$
$$\tan(A \pm B) = \frac{\tan A \pm \tan B}{1 \pm \tan A \cdot \tan B}$$

$\sin 2A = 2\sin A \cdot \cos A$	$\cos 2A = \dfrac{1 - \tan^2 A}{1 + \tan^2 A}$
$\cos 2A = \cos^2 A - \sin^2 A$ $= 2\cos^2 A - 1$ $= 1 - 2\sin^2 A$	$\tan 2A = \dfrac{2\tan A}{1 - \tan^2 A}$
$2\sin A = \sqrt{(2 - 2\cos 2A)}$	$2\cos A = \sqrt{(2 + 2\cos 2A)}$
$\dfrac{\sin A}{a} = \dfrac{\sin B}{b} = \dfrac{\sin C}{c}$	$\cos A = \dfrac{b^2 + c^2 - a^2}{2bc}$
$\cos\frac{1}{2}A = \sqrt{\dfrac{s(s-a)}{bc}}$,	$\sin\frac{1}{2}A = \sqrt{\dfrac{(s-b)(s-c)}{bc}}$,

where $s = \frac{1}{2}(a + b + c)$:

area $S = \frac{1}{2}bc \sin A = \sqrt{\{s(s-a)(s-b)(s-c)\}}$.

$2 = 1.41421 \ldots$, $\sqrt{3} = 1.73205 \ldots$,

$\sqrt{5} = 2.23607 \ldots$

THE HISTORY OF GREAT BRITAIN AND IRELAND.—CHAPTER I.

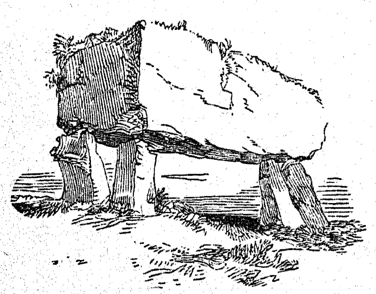
EARLY BRITAIN—CÆSAR'S INVASION—ROMAN OCCUPATION—GROWTH OF INDEPENDENCE.

"THE stir of the world" results in facts. The story of man upon earth is a record of events. The chronicler's task is to tell of change leading to change. History is human life realized. Great empires have risen and fallen in the past, giving place to the great empires of the present. Out of the traditionary dimness of unremembered times there come to us fitfully some intimations of life diffusing itself adventurously over land and sea. Phœnicia toils over the tempest waves of the great deep, and carries its activity and civilization beyond the "Pillars of Hercules" to the tin islands of the western main. Here, a thousand years before the Christian era, these traffickers found people, originated trade, and excited industry. Of old Aryan stock, the Celts who possessed the Britannic Isles had, after many migrations, sought shelter and settlement in these sea-girt lands, and hoped for peace and freedom. The races who had crossed the sea from the Ebro, the Rhone, and the Rhine, while occupying these islands among them—though only a few miles intervened between their respective territories—were almost as completely separated from each other as if they inhabited different quarters of the world. It seemed as if, in their dispersion, there had been communicated to them differing associations, interests, and inspirations, manifested in active rivalry, and creating a localized patriotism bounded by mountain-slope or river-side, within which sympathy was confined and strength squandered. Under such circumstances tradition and mythology constructed a picturesque history, and a finely-festooned curtain of fable enfolded each settlement like the drapery of a tent. Within this veil Phœnicia penetrated. Its commercial pursuits set the desires and energies of the half-known nation to work, and thus initiated great changes for the future of the world. Five centuries before Imperial Rome had acquired firm footing in these isles Herodotus speaks, from Phœnician information apparently, of the Cassiterides (Scilly and Cornwall), and of the tin and amber brought to Greece from these remotest parts of the west of Europe. Britain and Ierne were known by name to Aristotle in the third century B.C. Julius Cæsar linked Britain to the history and civilization of the ancient world, and brought its records within the range of literature.

The story of the growth of Britain from Celtic clanship to civilized nationality is one of much interest and instructiveness. The Celtic tribes attached great importance to descent from common progenitors and the possession of blood relationship. They held to the primitive, patriarchal, and family bond of brotherhood, and the rudimentary idea of organized life among them was suggested by the family. Clanship or septism lent itself easily to migration and the having of all things in common. They were quick-witted, imaginative, and gifted with ready utterance in speech and song. Labour was, with them, in a great measure co-operative, and they not only colonized but worked in clan-fashion, and under the leadership of their chieftains. Their civilization was not of the same sort as that of their kin who had achieved the conditions of government existing in India, Persia, Greece, and Rome. In the latter the state had become the unit of government, and gens, clans, septs, tribes had been subordinated to the community as an organized whole; in the former tribal confederacy had been reached: consolidated power had not been imagined. We are not lightly, therefore, to receive as absolutely accurate the representations of the Romans regarding the savage condition of early Britain. Celtic differed from Roman civilization, and prejudiced eyes looking upon it misjudged it. It implied self-restraint and respect for the claims of others. Handicraft industry, co-operative labour, mutual rights and obligations, trade, art, and learning had their place among them, and the intercourse of life was regulated by law within each tribe and such other tribes as were in alliance with them. They had not the organization of the great nationalities. The time

"When wild in woods the noble savage ran"

has no place in our annals. It was a condition of clan life that improvement was not pervasive. It did not spread rapidly and leaven the whole mass; but in the articles manufactured by the Celtic races from bone, stone, and bronze, there are indubitable evidences of skill, art, and taste. The emigrants of those early times, enforced by sword and famine to leave their native soil and seek new homes beyond the western sea, could not carry with them tools for land-tillage or handicraft. They were lucky if they carried kindred and friends in health and safety ashore, and had weapons and power for self-defence when their inroad was disputed. They had to begin life anew and fit themselves to what they found, and yet they must have brought wise heads and skilful hands. They soon acquired mastery over metals, wove the pliant twigs of the underwood into baskets, moulded the clay into pottery (which they adorned with curious ability). Of wicker-work and hides they constructed coracles for fishing, and they hollowed huge trees into canoes for seafaring. They raised grain crops, bred horses for driving and the chase, reared cattle, tended flocks, trained dogs to hunt and oxen to draw the plough, fashioned tools for forest work and labour in the mines, knit hose and wrought in the loom those checked cloths which gained them the name of Britons (painted). Cæsar took with him a corselet richly adorned with British pearls, which he dedicated to Venus and showed as a spoil which proved the wealth of Britain. Their querns, their sepulchral urns, their incense vessels, their jewelry, their beads of shell and jet, their weapons and their defensive armour, as well as their barrows and cromlechs, their forts and their temples—on which antiquarian research is being expended now after the lapse of more than eighteen centuries—bear witness to the worthy work the Britons could do, amid difficulties and straits, in a land and at a time when capital was, even if possessed, not understood.



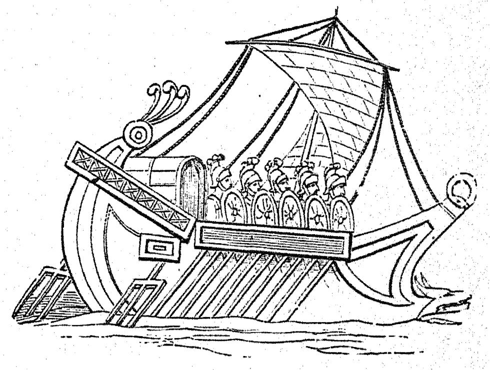
Cromlech.

Cæsar tells us they knew and could use the Greek letters, "the letters Cadmus gave;" that they enshrined their wisdom in mnemonic verse; that they kept records of the doings of their tribes, and recited the traditions of the past at banquets and holiday-festivals; that their Druids, bards, and vates formed a learned and influential class. That there were laws and judges, gentry and merchantmen, among them we know. They buried their dead with solemnity, had a faith in futurity, and public forms of worship. Their villages were collections of fern-thatched cots, often surrounded by ditch and palisaded wall. The *dun* of the tribe was an inclosed stronghold, fortified with stockade and mud-rampart, towards which the public roads tended, and into which in cases of extremity cattle might be driven, and women and children be brought for safety. Near them fairs were held, to which the traffickers of other tribes and nations came for the sale and purchase of produce and wares. They yielded obedience and paid tribute to their chiefs, and looked with awe on their priests.

It must not be forgotten either that, though disjoined from continental life by the narrow but stormy sea which engirt them, the Celts of Britain did not withhold their sympathy and help from the Gauls—a race kindred to themselves, using the same speech, and impressed by the same religion. Cæsar himself informs us that in all his wars with the fierce and restless races of North-western Europe, who had been declared the enemies of the republic, the inhabitants of the British Islands had given their neighbours such help and aid as made it desirable that he should set himself to stop the supplies. It was their friendly fidelity to Gaul which brought upon them the force of the Roman arms. They make their entrance into the pageant of continental history as the helpers of the weak against the strong—of the oppressed against the oppressor.

The foremost man of all the Roman world—Caius Julius Cæsar—in the course of his victorious career had engaged in "the Gallic Wars." In these, to some extent, he had been foiled by aid from Britain. Here was an opportunity of at once dazzling Rome with the splendour of daring and of keeping together those veteran troops attached to himself until they were trained as a standing army, willing to give him unconditional obedience, and therefore fitted to be his instrument in seizing on imperial power. He had learned in Gaul that clan communities were not, like those of Eastern states, subdued by one or two decisive engagements, but by persistent subjugation of one tribe after another, and often by means of each other. He had gleaned from the continental merchantry, to whom he had been a good customer, as much information about the country as he could. With the massive might of Roman legions directed against its divided inhabitants, this land of myth and mystery, he thought, could easily be brought under the sweep of his power, and Rome would bow before him.

On 26th August, 55 B.C., Julius Cæsar started from Gaul with the seventh and the tenth legions—8400 men in all, of whom about 800 were cavalry—in eighty transports, and landed on the east of Kent next day. He was steadily defied and stoutly resisted. The undisciplined valour of the clans could not prevail against the compact body of troops which the experienced tactician landed. On 27th August, somewhere on the coast of Kent, for the first time the Roman invader planted his foot on British soil. He was met in battle array again, and though he says he triumphed, and had a thirty days' thanksgiving decreed in Rome for having carried Roman arms beyond the confines of the civilized world, he took no booty, enforced no tribute, acquired no territory, and left Britain within three weeks. To retrieve his credit, in July, 54 B.C., Cæsar made a second invasion with thrice the number of men, and a fleet—800 sail in all—of flat-bottomed transports propelled by oars and sails. The Britons retreated; he followed. On the way to Canterbury his legions came up with the natives, and engaged them. A storm, however, had arisen and swept down on his vessels, dashing and damaging them much. He spent ten days, with all hands employed, in hauling up his wrecked fleet; he also pitched an exceedingly strong camp, wherein he left ten cohorts and 300 cavalry. After that, he set out in search of the troops of Cassivellaunus, who had been elected general of the clans. Several skirmishes took place, but the Britons were repulsed. Their arms were dirks, short broadswords, spears, axes, javelins, and darts. Their shields were of skin stretched upon plaited wands. They used horns for trumpets, and they had war-cars which they managed with skill. They were gymnasts well-drilled to movement singly, but wanting in discipline in company. In their own way they were learned in the art of war. A strong attack was made on a foraging party of Cæsar's legions, but no essential success followed. Cassivelaunus then began a series of strategies, and led Cæsar inland. Crossing the Thames, near Walton,



Roman Galley.


BRITANNIA ANTIQUA,
ANCIENT BRITAIN.
Roman Miles.
British Miles.
GERMANICUS OCEANUS
NORTH SEA OR GERMAN OCEAN
HIBERNICUS OCEANUS
IRISH SEA
OCEANUS VERGINIUS
St. GEORGES CHANNEL
Sabrina Æstuarium
Bristol Channel
BRITANNICUS OCEANUS
ENGLISH CHANNEL
Fretum Oceani
Strait of Dover
Vallum Antonini
Orrea
Alauna
Tuessis
Berwick
Coria Damniorum
Vanduara
Colania
Vidotara
Corda
Uxellum
Trimontium
Bremenium
Habitancum
Segedunum
Vedra Fl.
Tyne R.
Epiacum
Hexham
Pons Ælii
Vindomora
Novantum Pr.
Mull of Galloway
Novantum
Port Patrick
NOVANTÆ
Luguvallium
Olenacum
Old Carlisle
Brocavum
Verterae
Lavatrae
Bowes
Cataractonium
Catterick
Mona
Man
Brigantes
Isurium
Aldborough
Eboracum
York
Derventio
Gabrantuicorum Sinus Portuosus
Bridlington Bay
Morecambe Æstuar
Morecambe Bay
Setantiorum Est.
Belisama Æst.
Mersey R.
Coccium
Calcaria
Tadcaster
Delgovitia
Petuaria
Brough
Legeolium
Castleford
Cambodunum
Danum
Doncaster
Ocellum Prom.
Spurn Head
Abus Fl.
Humber R.
Mancunium
Manchester
Rigodunum
Warrington
Praesidium
Praetorium
Agelocum
Littleborough
Lindum Coritanorum
Lincoln
Mona
Anglesea
Segontium
Caernarvon
Conovium
Deonna vel Deva
Chester
Condate
Northwich
Derventio
Ad Pontem
Southwell
Margidunum
Bridgeford
Metaris Æstuarium
The Wash
Branodunum
Brancaster
Garrienum Fl.
Yare R.
Garianonum
Burgh
Ganganorum Pr.
Braich y Pwll
Andros I.
Bardsey I.
Mediolanum
Rutunium
Pennocrucium
Etocetum
Wall
Uriconium
Wroxeter
Vernometum
Willoughby
Ratae vel Ratae
Leicester
Durobrivae
Castor
Camboricum
Icklingham
Venta Icenorum
Caister
Maglona
Machynlleth
Manduessedum
Mancester
Venonae
Branogenium
Leintwardine
Praesidium
Warwick
Tripontium
Duroliponte
Cambridge
Sitomagus
Magna
Kenchester
Bannaventum
Daventry
Lactodorum
Towcester
Salenae
Sandy
Iciani
Chesterford
Combretonium
Stratford
Octapitarum
St. Davids Head
Maridunum
Caermarthen
Isca Fl.
Ariconium
Ross
Blestium
Monmouth
Glevum
Gloucester
Magiovinium
Villa Faustini
Colonia
Colchester
Gobannium
Abergavenny
Corinium vel Durocornovium
Cirencester
Verulamium
St. Albans
Camulodunum
Maldon
Tobii Ostia
Burrium
Usk
Isca
Caerleon
Venta Silurum
Caerwent
Sulloniacae
Brockley Hill
Durocobrivae
Londinium
London
Canonium
Kelvedon
Jamissa Æstuarium
Thames
Abone
Avonmouth
Trajectus
Cunetio
Marlborough
Spinae
Speen
Pontes
Old Windsor
Noviomagus
Vagniacae
Durobrivae
Rochester
Durovernum
Canterbury
Rutupiae
Richborough
Dubrae
Dover
Portus Lemanis
Hythe
Aquae Solis
Bath
Calleva
Silchester
Vindobis
Farnham
Madus
Maidstone
Herculis Pr.
Hartland Pt.
Lindinis
Ilchester
Sorbiodunum
Old Sarum
Brige
Broughton
Venta Belgarum
Winchester
Clausentum
Southampton
Regnum
Chichester
Anderida
Eastbourne
Portus Novus
Rye Harbour
Isca Dumnoniorum
Vindogladia
Uxela
Exeter
Durnovaria
Dorchester
Portus Adurnus
Portsmouth
Vectis Insula
Isle of Wight
Portus Magnus
Voliba
Tamara
Tamari Ostia
Plymouth Sound
Cenonis Ostia
Falmouth Harbour
Ocrinum Pr.
Lizard Pt.
BELGÆ
ATREBATII
REGNI
DUROTRIGES
DAMNONII
DEMETÆ
SILURES
ORDOVICES
CORITANI
ICENI
CENIMAGNI
TRINOBANTES
CATIEUCHLANI
DOBUNI
CANTII
CORNAVII
GANGANI
PARISI
CONDEATI
SELGOVÆ
OTADENI
DAMNII
Longitude West from Greenwich
Longitude East from Greenwich

the Britons confronted their pursuers. Cæsar commanded his cohorts to dash through the stream, and they won. The Britons devastated the country as the Romans advanced, and hung on the skirts of their army to attack and intercept stragglers. In their war-cars the Britons flashed out on the legions, and harassed them terribly. The Trinobantes deserted Cassivelaunus, and Cæsar spared their houses and fields on condition that they gave him forty hostages and a supply of corn. They consented to his terms. Other clans sought to make similar terms with Cæsar, and he granted them. His antagonist in vain created a diversion by raising the southern tribes; Cæsar pressed on the capital of the Cassi, and took it. But he offered peace to his opponent on condition of his paying a fixed annual tribute. Cæsar retraced his way to the sea. He set sail on 21st September, carrying no tributaries with him to Rome "to grace in captive bonds his chariot wheels," and leaving no Roman soldier behind him in Britain, to which he never returned. For nearly a century thereafter no Roman force appeared in the Britannic isles.

Among the hostages taken with him by Cæsar to Rome was, according to our earlier historians, Cymbeline, the grandson of Cassivelaunus,

> "Famous in Cæsar's praises, no whit less
> Than in his feats deserving them."

He was brought up in Rome, and there made knight by Augustus Cæsar, under whom he served in the wars. At Rome, Cymbeline married his cousin Cartismandua, also a hostage. At this time Augustus, urged by many Roman nobles, prepared an expedition for the invasion of Britain, and had reached Celtic Gaul on his journey, when, hearing of the rebellion of the Slavs of Pannonia and Dalmatia, he turned his arms to the East. Again, six years afterwards, he renewed his designs upon Britain, but the invasion was put off; and when, next year, he was on his way again, insurrections nearer home required his presence. Cymbeline was called to succeed his father Theomantius as king in the land of his nativity. On his arrival he coined a golden tribute-money, specimens of which are to be found in the cabinets of numismatists. These bore his own effigies diademed with pearls. Probably among the Chiltern Hills in Buckingham Cymbeline held his court. Adminius, his eldest son, having rebelled, was exiled, and put himself under the protection of Caligula. At his suggestion, this showy wearer of the military shoe, but feeble wielder of the imperial sceptre, made a feint at the invasion of Britain, from which, on getting out a few miles to sea, he desisted. Gathering a few shells on the coast of Gaul, he returned to Rome to receive the honours of a Britannic triumph. On Cymbeline's death (2 A.D.) Cartismandua married Cadallan, chief of the Brigantes, and thus became stepmother of *his* son Caractacus, and of Boadicea. Rome then encouraged and afforded an asylum to all intriguants and rebels against the British chiefs. Bericus, a rebel, found protection from Claudius. Togodumnus demanded delivery of him. Claudius refused. The Britons retaliated by prohibiting commerce with Rome; and hence arose the crisis which, after ninety-seven years' immunity, brought a Roman invading force to Britain.

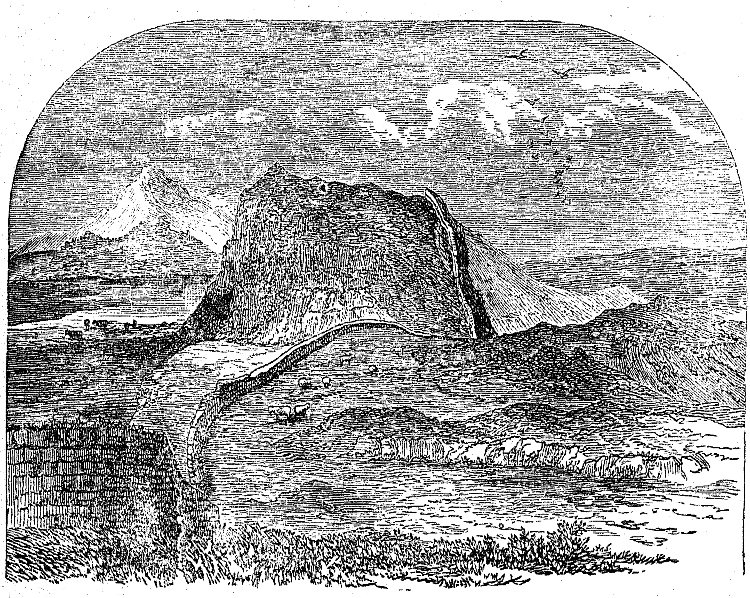
In this interval the British, though slowly, learned somewhat of the secret of Roman civilization—organization. They had no national centre of authority, but leagues were entered into more freely. Confederations under overlords were agreed upon, and the eyes of the Britons were turned to the Continent as a field for trade. They began to export grain, skins, cattle, and hunting-dogs; gold, silver, lead, and iron, besides tin; and some of them found that, when they had spared the lives of those taken in fight, it was more immediately profitable to deport them as slaves than to use them as tillers of the ground. The land to whose existence Cæsar "as a discoverer, rather than a conqueror," had opened the eyes of the Romans became a reality in the universe.

The Romans, under Aulus Plautius and Cneius Sentius, accompanied by Vespasian and Titus (afterwards emperors), arrived in Britain, guided by Bericus, and resolved on its subjugation, 43 A.D. Four legions, with cavalry and German auxiliaries, 50,000 men in all, formed the invading force. They were valiantly resisted by the natives; but, tribe by tribe, the Romans subdued them in detail, and the south was almost wholly theirs. The Emperor Claudius Nero came to see with his own eyes the achievements of his forces. In his presence Camulodunum (Colchester) was stormed. Thither Caractacus and Togodumnus, the sons of Cymbeline, had retreated, and there they were slain. Some tribes were received into submission, and Claudius went back to Rome to enjoy the glory of a triumph as the conqueror of the Britons. Neither Vespasian nor Plautius, however, could succeed in making a lasting conquest. Overcome in one place they revived the struggle in another. Plautius was recalled, but he being sick died, and was buried at Maldon. Ostorius Scapula was sent to succeed him as pro-prætor. He opened the compaign at once, crushed the insurgent Britons, and ran a line of forts from the Severn to the Nene, disarming all suspects within these bounds. This struck terror into their souls, but it was the fear that stirs to fierce fight. In an encounter at Caer-Caradoc, in Shropshire, 51 A.D. Caractacus, after a severe struggle, was defeated, and, sorely wounded, escaped to Dunstaffnage only to be given up to the Romans by his stepmother. His wife and daughters were taken prisoners, and his brothers surrendered at discretion. The heroic prince, with his unfortunate family, were sent to Rome to grace a triumphal pageant. Even in Rome, as a prisoner, his noble demeanour and dauntless spirit commanded the admiration of the lords of the world. So noble and dignified were the words in which he stated his case to the emperor, that Claudius immediately pardoned him and his friends. His after-fate is unknown.

The Silures, notwithstanding the defeat and capture of their chief, continued to skirmish and make reprisals. Claudius declared that Rome would "blot out their very name," but the boast remains yet unfulfilled. Ostorius, worried and wearied out, died about 53 A.D. of chagrin. Didius succeeded him, but appears to have made no signal impression by warfare. He set military stations near the *duns* of the tribes, planted colonies at the chief strategical points, and joined camp to camp by well-made roads, with military stations and guards to take charge of them. Outbreaks and revolts, however, continued still. In Nero's time, about 57 A.D., Veranius replaced Didius, but died early, and was replaced by Paulinus Suetonius. He was ambitious. He took Mona, the island headquarters of Druidism, and cut down their groves. A rising among the Iceni called him to the south-east. On the death of Prasutagus, king of that tribe, the Romans began to plunder and pillage, enslaved his kinsmen, brutally ill-used his daughters, and subjected his widowed queen, Boadicea, to the scourge. This evoked the fury of the tribes. The cry for vengeance came from every heart, and they bound themselves to make common cause against their oppressors. Boadicea fell on Camulodunum, after two days' siege took it by storm, and in the carnage that ensued 70,000 perished. The ninth legion, on its way to disperse the besiegers, was met, opposed, and almost annihilated, Petilius Cerialis, their commander, under whom Tacitus the historian served, being forced to retreat and intrench himself in Verulam. Thither he was followed, and Boadicea, now joined by the Picts and Scots, attacked that *municipium* (free city) of the Romans, and laid it waste with fire and sword. With similar ruthlessness she treated London, which Paulinus Suetonius had reached, and from which he had led forth his army. Turning towards the camp the foe had formed, the victress led her followers on in the rashness of her passion. She fought, she said, for the general freedom, in revenge for her ignominious stripes and the unforgivable injuries inflicted on her daughters. "Here we must conquer by bravery or die with glory. Whatever ye may do, O men, I, a woman, will not survive in infamy or live in bondage." The engagement began. It was short and decisive. The Britons were put to flight and slaughtered mercilessly. The daughters of Boadicea were captured fighting on the field. Boadicea relieved herself from the contumely of becoming a spectacle in a Roman triumph by poison, and was honourably interred, some say, at Stonehenge.

Julius Agricola took the report of these proceedings—probably prepared by Tacitus—to Rome. Paulinus Suetonius

was recalled; Petilius succeeded him, and he was replaced by Julius Frontinus. At length Agricola, having been raised to patrician rank and served in the consulship, was appointed governor of Britain. He arrived in 78 A.D., and held rule under the emperors Vespasian, Titus, and Domitian. Tacitus, Agricola's son-in-law, has written these pages of British history in pregnant Latin. The chieftaincies of South Britain were subdued, and to some extent Romanized; but the wild Caledonians, who dwelt in the hill country of the north, often harried the subjugated tribes. Agricola marched against them. He encountered Galgacus, "fighter of battles," the nephew of Boadicea, in a pitched battle near the Grampian Hills, and with the slaughter of 100,000 men reduced the north to Roman rule. To secure his province from aggression, he erected a chain of forts, and built a wall between the



Hadrian's Wall, Northumberland.

Forth and the Clyde. He employed his fleet—itself a striking symbol of the Roman power—to explore the north coast. It sailed round the island. The Orkneys were sighted in their course, and Ireland was seen to be really an island suggestive of another conquest. In Ireland he saw a land, lying between North Britain and Spain, which would round off the Roman Empire nicely on the north-west; and he lined the coast of Scotland opposite it with troops, expecting some day to pass over to and subdue it. But "Caledonia, stern and wild," sullenly nursing designs of renewed aggression, supplied him with quite enough to do to keep the land he had.

Coin of Hadrian.

Its hardy tribes tripped over the border, carried devastation far and wide, and, when opposed, dispersed and found their way home well-laden with booty and but slightly harmed. Hadrian, first among the Roman emperors to bear the illustrious title of *Britannicus*, in 120 A.D., on a tour of inspection, visited Britain, and advised the resigning of the territory between the dyke of Agricola and a massive wall paralleled with a ditch and an earthwork, which he caused to be raised—with bridges where required—between the Solway and the Tyne. Even this was found insufficient as a barrier against incursions, and Antoninus Pius caused another one to be constructed nearly on the lines of that which Agricola had formerly fortified. The manning and holding of such a wall we know must have demanded immense resources in men and means. The disturbed state of Britain under a foreign yoke continued long, and demanded heavy drains on the empire. At length, Severus—head of that empire in which subjugation was a creed—enraged at the continued irruptions of the Caledonians, determined himself—despite of years and gout—to undertake the settlement of this western fringe of the imperial dominions. Accompanied by the Empress Julia, his two sons, and two legions, he entered on his task 208 A.D. He built a fresh wall between Blackness and Kilpatrick, along which he laid a paved military road. Several encounters took place; but the enemy wasted before him in concerted retreat. With slakeless rage he pursued, and though no battle was really fought, 50,000 Romans succumbed in the expedition. The Caledonians, it is said, at last, under force of fire and sword, agreed not to invade the intra-mural territory again. When he was about to sign the treaty, his son Caracalla suddenly drew his sword to slay his father. Severus turned, saw the flash of the weapon, guessed the intent of it, looked int the eyes of the would-be parricid ho stood paralysed, and then, pr ding with the business before hi rote his signature, and received t symbolic sword of submission. his return to his tent he rebuked son, that lust of reigning should l led him to do such a deed in the nce of the foe and the eye of the ld. Severus died in the imperia lace at York, 212 A.D., "leavir as he said, "the empire in peace, among the Britons."

Towards the close of the d century Britain became exposed to new influences. 'ranks and Saxons, seeking an outlet for their redundan lation, commenced a series of descents upon the sout coasts of Britain. The emperors Diocletian and M an stationed an army and sent a fleet under the comn of an official as guardian of the Saxon shores. One of ese, a Menapian, as those who dwelt near the mouth of the Rhine were called, was Carausius. He prevailed on the British to proclaim him emperor 287 A.D., and the coast-lands of Gallia were soon subdued to his dominion. Constantius, co-emperor of Rome, resolved to crush Carausius, and to give the British good reason for hesitation in again interfering with the rulership of Rome. He came in person to Britain, and there saw at Colchester Helena, daughter of King Coel, whom he espoused. She was thus a king's daughter, a Cæsar's wife, and an emperor's mother. Constantius won and kept the good-will of the Britons, and was a kindly governor to them. Allectus, by the assassination of Carausius, had freed him from any difficulty as regarded the immediate purpose of his coming. He took up his residence at York, and here, it is often said, Constantine the Great, first Christian emperor of Rome, was born. Constantius died 306 A.D., and was buried at York. During his reign, Britain enjoyed peace. But not long after his death the Caledonians—who now consisted of Scots who had emigrated from Ireland and occupied the south-west of the country now called Scotland, and the Picts who dwelt on the eastern side—made incursions into the south, and sometimes extended their raid to the Thames. On one occasion, it is stated, they succeeded in plundering London. The Roman general, Theodosius, repelled these invaders 367 A.D., and next year reconquered the territory they had overspread. This he called Valentia, in honour of the Emperor Valen-

tinian. This success was only temporary. The difficulties arising from the division of the empire—which gave to history the task of unravelling the intricate involvements of the Empire of the East and the Empire of the West—the increasing troubles in Gaul, the insurrections against Roman domination arising on all the outskirts of the imperial territory, the insurrections, the quarrels, and the revolts of the different governors of the island (some of whom, by aid of the arms and fleets of Britain, strove to attain the purple), joined to the growing intensity of the attacks made by the bordering tribes in the north and the west, all conspired to shake the tenure of Roman power in the British Isles. Unable to defend the long line of their frontier against the many inroads made by savage hordes and revolting subjects, Rome was obliged to withdraw her active troops from Britain. In 410 A.D. Honorius informed the Romanized Britons that they must henceforth depend on themselves for protection; and about 420 A.D., somewhat less than five centuries after Cæsar's first invasion, the power of Rome had ceased in these islands which "the mightiest Julius" had nominally added to the mother-empire.

It had been the practice of the Roman government during the latter years of the empire to repay the troops who had fought and laboured in the many strifes of the state by grants of conquered territory on which to form colonies, and to transplant the trained soldiery of one nationality into the territory of some other subjugated race. In this way upwards of forty legions of Thracians, Dalmatians, and natives of Eastern Germany had been deported upon British soil. Not only these, but many of the soldiery who had been captured in the wars of the tribes, who had acquired interests in the country, or who had found opportunity for desertion, had doubtlessly remained behind in the land of their enforced or voluntary adoption; and there were many who came in the train of the Roman armies—merchants, artificers, corn-dealers, camp-servants, attendants on official persons, &c.—who also found it necessary or advisable to stay and make the best of it in the west. Their mingling with the people of the tribes, and the greater intercommunication of tribe with tribe rendered necessary by the leagues, alliances, conferences, and distresses arising from the warfare engaged in among themselves or against Rome, contributed greatly to destroy the clanship of birth-blood, and render possible among them the cohesion of nationality.

Our protracted relationship with Rome did not largely influence our social life. We were Romanized in ways rather than in race. The courage, hardy training, and frugality of mighty military organizations on the one hand were equalled on the other by the servility to lust, luxury, and pomp shown in the city civilization. Roman tyranny evoked, or at least consolidated, our system of local self-government. Rome brought us into relation with soldierly power, and naval capacity, immense force trained to stupendous accomplishments, and they left us their highways, camps, stations, and walls, their altars, their mural tablets, their military discipline, as object-lessons in national progress. They brought within the ken of the people the uses of coined money, regular markets, some industrial arts, and some amusements. Its civic conveniences, municipal rites, methods of communication, style of warfare, fashions of intercourse, and modes of festivity have also affected us somewhat. To it, we owe the faith which has had the most marvellous influence on social existence. Early the messengers of the cross came to evangelize these isles of the sea, and eagerly in many instances were their ministrations welcomed. Simon Zelotes died a martyr here. Embassies went hence to Rome on religious affairs. At Arles, Nice, and Sardica British members signed the canons. The Culdee missionaries carried gospel light afar. St. Alban suffered martyrdom in 304 A.D. Thus indeed, long prior to the imperial adoption of Christianity by Constantine, 313 A.D., nominal attachment to the church became prevalent. Britain had taken kindly to the creed which taught of Christ. This intensified and purified family relationships, and sanctified the bonds of friendship and neighbourhood. It gave a higher conception of life, a nobler ideal of law, a loftier example of conduct, and a worthier knowledge of God.

THE GREEK LANGUAGE.—CHAPTER I.

ALPHABET.

The Greek alphabet contains twenty-four letters, which are arranged and named as undergiven:—

Capitals.	Small Letters.	English Equivalent.		Greek Name.	English Pronunciation.
Α	α	A	a	ἀλφα	alpha
Β	β	B	b	βητα	bēta
Γ	γ	G	g	γαμμα	gamma
Δ	δ	D	d	δελτα	delta
Ε	ε	E	ĕ	ἐψιλον	epsilon
Ζ	ζ	Z	z	ζητα	zēta
Η	η	E	ē	ἠτα	ēta
Θ	θ	Th	th	θητα	thēta
Ι	ι	I	i	ἰωτα	iota
Κ	κ	K	k	καππα	kappa
Λ	λ	L	l	λαμβδα	lambda
Μ	μ	M	m	μυ	mu
Ν	ν	N	n	νυ	nu
Ξ	ξ	X	x	ξι	xi
Ο	ο	O	ŏ	ὀμικρον	omikron
Π	π	P	p	πι	pi
Ρ	ρ	R	r	ῥω	rho
Σ	σ, ς	S	s	σιγμα	sigma
Τ	τ	T	t	ταυ	tau
Υ	υ	U	u	ὐψιλον	upsilon
Φ	φ	Ph	ph	φι	phi
Χ	χ	Kh	kh	χι	chi
Ψ	ψ	Ps	ps	ψι	psi
Ω	ω	O	ō	ὠμεγα	omega

Greek pronunciation is extremely simple: the letters of the alphabet have the sounds given opposite them as the English equivalents, and if the beginner will at once make himself acquainted with the appearance of the letters he should have little further difficulty with this. He should be careful always to sound η like *ay* in *pay*, and to sound ι like *ee* in *feet*.

Letters are either *vowels* or *consonants*.

There are seven vowels, of which two, ε, ο, are short; two, η, ω, are long; and three, α, ι, υ, are doubtful.

The short vowel ε has its corresponding long η, and ο short ω long. Each doubtful vowel is naturally short, but is sometimes long; thus α in πατηρ, a father, is always short; α in λαος, a people, is always long.

Two vowels pronounced together make a *diphthong*. If each vowel is equally sounded the diphthong is *proper*; if not, *improper*. There are in all twelve diphthongs—six proper and six improper.

The six proper are formed from the short vowels and α (short) by subjoining ι and υ; thus ε, ει, ευ; ο, οι, ου; α, αι, αυ.

Of the improper diphthongs three are called surds, viz. ᾳ, ῃ, ῳ, because the subscript vowel ι is scarcely heard in the pronunciation; the other three improper diphthongs are ηυ, ωυ, υι.

The simple consonants are either *semivowels* or *mutes*.

The four liquids, λ, μ, ν, ρ, are reckoned as semivowels; so is the sibilant σ, which, as having a sound peculiar to itself, is sometimes called *solitarium*. Sigma at the end of a word is always written ς; at the beginning or in the middle σ.

There are nine mutes, divided into three classes, the soft, middle, and aspirate—the soft, π, κ, τ; the middle, β, γ, δ; the aspirate, φ, χ, θ.

Each soft mute, with its middle and aspirate, as they are pronounced with the same organ of the voice, forms an order: first, *labials*, because pronounced chiefly by the lips; second, *palatals*, as their sounds proceed from the roof of the mouth; and third, *dentals*, as they are pronounced chiefly by the teeth.

The three double consonants, ψ, ξ, ζ, are formed by subjoining ς to the three foregoing orders of the mutes; thus π β, φ; κ, γ, χ; τ, δ, θ, with ς make ψ, ξ, ζ. Γ before a mute of its own order is pronounced as in the syllables *ing*, *ang*, *ung*; thus ἀγκος, ἀγγελος, ἐγχος.

Each double consonant may be resolved into the mute from which it was formed and ς; as the ψ in λαιλαψ is equivalent to πς, the ξ in ἀναξ to κς, &c.

The only consonants in which Greek words can end are ν, ρ, ς, ξ, ψ, and κ in the preposition εκ and in the adverb ὀυκ.

OF ACCENTS.

In the earlier lessons, that we may not unduly trouble the learner with minutiæ in which he can take little interest, and the peculiar uses of which he cannot understand or appreciate, we shall not closely adhere to the laws of accentuation, but shall rather, in a special lesson, explain fully and exhibit clearly the chief regulations concerning accent, in a series of exemplified rules. Keeping in mind only this general rule, "The emphatic syllable of every Greek word is accented, even monosyllables if they are independent," and taking the following definitions as explanatory of their character, this matter shall in the meantime be disregarded.

The *accent*, or tone of the syllable, is threefold—viz. the *acute* ('), which indicates a rising and sharp intonation of the voice in pronouncing a syllable, as τύπτω, I am striking; the *grave* (\`), a falling of the voice, as τιμὴ, honour; the *circumflex* (῀), uniting the tones of both, and originally formed by the junction of the two, as ποιῶ, I am making.

In Greek the accent is placed only on one of the last three syllables of a word.

In accentuation words are called *oxytone* when the accent is placed on the last syllable, as θεό; when on the penult, *paroxytone*, as λόγος; when on the antepenult, *pro-paroxytone*, as ἄνθρωπος.

Barytones are words which have no accent on the last syllable, as τύπτω.

When the circumflex is placed over the last syllable, words are called *perispomena*, as φιλῶ; when on the penult, *properispomena*, as σῶμα, πρᾶγμα.

There are two *breathings*, the *rough* and the *smooth*. The former has the power of the letter *h*, while the latter indicates that the vowel is to be pronounced without the rough breathing. Every vowel at the beginning of a word is marked by a breathing-sign, represented by an apostrophe turned inwards (῾) for the rough, and outwards (᾿) for the smooth. It is of the greatest importance to notice the aspirate or rough breathing, as that affects pronunciation; thus ἁμα is sounded *hama;* ἐγω, *egō.* Initial υ has always the aspirate, as ὑδωρ, sounded *hudōr;* likewise also the initial consonant ρ, as ῥοδον, but the *h* is not audible here.

The *points* or *pauses* are four—the comma (,); the mark of interrogation (;); the colon, thus placed (·); the period (.)

CONTRACTED SYLLABLES.

In general, when the following vowels or vowels and diphthongs come together they are contracted into one, thus—αα, αε, αη into ᾱ; αϊ, αει, αῃ into ᾳ; εα into ᾱ; ηε, εα into η; εαι, εῃ, ηϊ into ῃ; ιϊ, ια, ιε into ῑ; αο, αω, αου, εω, οα, οη, οω, ωα into ω; αοι, ωϊ into ῳ; οαι into αι; εε, εϊ, εει into ει; εοι, οϊ, οει, οῃ, οοι into οι; οο, εο, εου, οε, οου into ου; υα, υε, υη, υϊ into ῡ; υϊ into υι.

When the letter σ occurs in inflected words between two short vowels it is for the most part elided, and contraction takes place as noted above.

In the lengthening of vowels in the course of inflexion ᾰ becomes ᾱ or η; ε, η or ει; ῐ and ῠ, ῑ and ῡ; and ο, ω or ου.

THE PARTS OF SPEECH.

There are eight parts of speech—

DECLINABLE.	INDECLINABLE.
Noun.	Adverb.
Adjective (including Article).	Preposition.
Pronoun.	Interjection.
Verb.	Conjunction.

Nouns are varied to indicate gender, number, and case.

The three genders are—masculine, feminine, and neuter. The masculine and neuter are generally known by the terminations. The three numbers are—singular, dual, and plural. The dual occurs when two or a pair are spoken of. It was chiefly employed by the Attic writers.

The five cases are—nominative, genitive, dative, accusative, and vocative.

OF DECLENSION.

There are three declensions. The declension to which a noun belongs is known by the inflexion of the genitive singular.

GENERAL RULES.

(1) The dative singular always ends in ι, usually written under the preceding vowel; as τιμῃ.

(2) The vocative singular is generally—in the plural always—like the nominative.

(3) The nominative, accusative, and vocative of neuter nouns are always alike; and these cases in the plural end always in α.

(4) The genitive plural always ends in ων.

(5) The nominative, accusative, and vocative dual are always alike; as also the genitive and dative.

FIRST DECLENSION.

The First Declension has four terminations: two feminine, η, α, and two masculine, ης and ας.

Some nouns and adjectives, chiefly found in Homer, ending in α are masculine, as ἱπποτα, ποιητα; hence Lat. *poëta*, &c.

NOUNS OF THE FIRST DECLENSION.

	1. *Feminine.*	2. *Masculine.*	3. *Feminine.*	4. *Feminine.*	5. *Masculine.*	6. *Masculine.*
Singular.	honour.	Muse.	wisdom.	day.	citizen.	young man.
Nom., . .	τιμη	Μουσα	σοφια	ἡμερα	πολιτης	νεανιας
Gen., . . .	τιμης	Μουσης	σοφιας	ἡμερας	πολιτου	νεανιου
Dat., . . .	τιμῃ	Μουσῃ	σοφιᾳ	ἡμερᾳ	πολιτῃ	νεανιᾳ
Acc., . . .	τιμην	Μουσαν	σοφιαν	ἡμεραν	πολιτην	νεανιαν
Voc., . . .	τιμη	Μουσα	σοφια	ἡμερα	πολιτα	νεανια
Dual.						
Nom. Acc. Voc.	τιμα	Μουσα	σοφια	ἡμερα	πολιτα	νεανια
Gen. Dat., .	τιμαιν	Μουσαιν	σοφιαιν	ἡμεραιν	πολιταιν	νεανιαιν
Plural.						
Nom. Voc., .	τιμαι	Μουσαι	σοφιαι	ἡμεραι	πολιται	νεανιαι
Gen., . . .	τιμων	Μουσων	σοφιων	ἡμερων	πολιτων	νεανιων
Dat., . . .	τιμαις	Μουσαις	σοφιαις	ἡμεραις	πολιταις	νεανιαις
Acc., . . .	τιμας	Μουσας	σοφιας	ἡμερας	πολιτας	νεανιας

Nouns ending in η are inflected as in column 1. Ex.—κεφαλη, a head; λυπη, grief; νικη, victory; πυλη, a gate; δικη, a decision; γνωμη, an opinion; μορφη, a form.

Nouns in α *preceded by a consonant* are declined like those in η, but have αν in the accusative singular, as in column 2. Ex.—μελισσα, a bee; θαλασσα, the sea; θυελλα, a storm; δοξα, an opinion; γλωσσα, a tongue; ῥιζα, a root; ἁμαξα, a waggon; βασιλισσα, a queen.

Nouns in α pure (*i.e. preceded by a vowel*) and in ρα have ας and α in the genitive and dative, as in columns 3 and 4. Ex.—αἰτια, a cause; ἐλαια, an olive; σκια, a shadow; καρδια, the heart; πελεια, a dove; ἀγορα, a market-place; μαχαιρα, a short sword; θυρα, a door; γεφυρα, a bridge; χωρα, a country; λυρα, a lyre; κωμῳδια, comedy; παιδεια, instruction.

Masculines in ης and ας have ου in the genitive, and drop ς in the vocative; της has α in the vocative, στης has either η or α (see cols. 5 and 6). Ex.—ταμιας, a steward; βορεας, the north wind; ποιητης, a poet; δεσποτης, a master.

ENGLISH LITERATURE.—CHAPTER III.

THE FORMATIVE PERIOD OF ENGLISH LITERATURE.

SECTION I.—POETRY IN LIFE AND LETTERS—"PIERS PLOWMAN," GOWER, BARBOUR.

The earliest living breath of popular poetic feeling takes the rhythm of the ballad. History sees in it memorials of public transactions, the records of the romance and glory of life. The rude songs which rouse the martial spirit and fan the flame of patriotism have almost all originally a narrative basis. No festivity is perfect, in castle-hall or on village-green, without the minstrel's harp. Marvellous tale, wild adventure, excited feeling, turbulent exploit, valour and fidelity, are set to music and chanted to the charmed listeners. Ballads are the epics of the common people, sang by the nameless Homers of the hamlet, the forgotten Virgils of the villages, and the tender Tassos of the tribes by whom the hardy heroisms, the tragic stories, and the true-love fidelities of life and time were consecrated in rough vigorous verse. These storied songs, which fell on the ears of the hearers and quickened their hearts, were written only on the palimpsests of memory, in which erasures and rescripts are easy. Hence the variousness of the texts of ancient ballads. The vagrant wanderings of the minstrels led them into various places, and their desire to gratify their hearers' family, tribal, or local pride inclined them to keep all references of a personal, scenic, or chronological kind as fluent and readily changeable as possible. Thus various readings abound in ballads, and claims from many country-sides are put forth as the scenes of their story or the dwellings of their writers. They were shaped and reshaped, and not being preserved by printing, were produced and reproduced in new casts, with fresh allusions and in altered rhythms, until their incidents and their form became as common as wild flowers, though in feeling, phrase, and fanciful adornment they, like the wildlings of the meadow and the hillside, acquired traces of the race of the soil in which they were nourished, and in which they flourished.

Such unwritten poetry permeated the whole body of the people. When no man writes what every one knows, it then comes to be that no one knows what none has written. This is the reason why so many of our old ballads have faded away from memory and possession. Only after the products of mind have been garnered up in written form do they become literature. Song-enshrined life first craved for registration in poetic penmanship. Ours became a national literature because it took its true impulse from the simple familiar experiences of the common people; expressed their feelings, realized their love of freedom and truth, sang in harmony with their sympathies, and put into the rapid rush of narrative the passionate force of free personality. History thus got trimmed into story, and took the shape of tale and romance, rather than of record. The old Roman "Gesta," the Provençal traditions, the choice incidents of the chroniclers, the mirth-provoking folk-songs and mock-songs of the market-place, were all influential on the minds of those who wrote the early light literature of living England; but the popular ballad, whatever the matter might be, gave form, tone, and tendency to our earliest poetry.

The fourteenth century was the formative era of England's living speech. It was, in South Britain, the age of Edward I., the energetic; Edward II., the feeble; Edward III., the valorous; Richard, "the redeless;" and Henry IV., the astute; in North Britain, it was the period of the patriotic Wallace, the chivalrous Bruce, the luckless David II., and the peace-seeking Robert II. It was a time of stir and strife, of singular story, of patriotism made picturesque, of vexing vicissitudes and unsettledness of life. During the larger section of this century the imagination and emotions were vigorously stimulated, and exercised an active influence on men's minds. The nation had absorbed Roman grandeur, Saxon strength, Danish energy, Norman vivacity, Cymric spirit, Christian faith, and active industrialism. The vital interests of men were growing more complex; the policy of government more intricate; the anxieties of men were more exquisite, and the need for modifications in the old plan of life made itself felt in various ways. The cleverest, ablest, and noblest of the world's minds were most touched by these influences. In different ways they wrought into the mass of national life. By sword and sceptre, plough and pen, church organization and commercial guild, civic corporation and feudal federation, endeavours were made to work the world round to better things. The records of the results of many agencies have been lost. From charters and statutes, musty records and much-mildewed papers, we gather here and there scraps of fact and snatches of incident; but literature best teaches us how to reimagine the real life of the past, and the masterpieces of a nation's minstrels show us the thoughts, feelings, and aspirations of those who grasped a victory under the shadow of despair within sight of Stirling, who hazarded their lives in the hopelessness of Halidon Hill and Neville's Cross, who fought at Crecy, Calais, and Poitiers, or with Van Artevelde gained the splendid victory of Sluys; of those who saw the insurrections of Straw and Tyler, shuddered under the "merciless parliament," rejoiced in or wept for Bolingbroke's landing at Ravenspur, and greeted or grieved for the murder of "the well-graced actor" who, as Richard II., had been England's king.

Only a few inconsiderable fragments of the Scottish songs of these war-times survive. They served their purpose, and are (perhaps fortunately) forgotten. That there were many of them, Fabyan admits. He says—"This song was after many days sung in dances, in the carols of the maidens and minstrels of Scotland, to the reproof and disdain of Englishmen, with divers others which I overpass:

> "'Maidens of England! sore may ye mourn,
> For your lemans ye have lost at Bannockysbourne,
> With heave a lowe.
> What, weneth the King of Englande
> So soon to have wonne Scotlande!
> With a rum-be-lowe!'"

Laurence Minot thinks that "the Scots to make such boast were much to blame," perhaps referring to songs like this one, with which Edward I. was derided from the walls of Berwick during the siege of 1296:—

> "Wend King Edewarde, with his long shankes,
> To have got Berwycke, all our unthankes?
> Gae pikes him,
> And after gae dikes him."

In the prologue to the first part of his chronicle, Robert de Brunne mentions the "Romance of Sir Tristrem" as one which he had been many a time asked to turn into English rhyme, and he attributes the authorship of it to Thomas the Rhymer of Ercildoune (now Earlston, near Melrose, in Berwickshire). He is also named by Barbour, Wynton, Bower, and Major, both as a poet and a prophet. This poem is regarded as a precious relic of early British poetry belonging to the age of Edward I. It is distinguished by quaint simplicity and forcible brevity of style. Its verses are short, its transitions abrupt, its phraseology (as perhaps becomes a prophet) somewhat enigmatical. The prophecies of Thomas the Rhymer were long known and widely circulated among the people, who had great faith in the Scottish seer. He taught in mystic lines that a king should come who

> "Shall rule all Britain to the sea,
> That of the Bruce's line shall come
> As near as to the ninth degree."

Laurence Minot, whose Northumbrian English is singularly easy and various, is the achievement-poet of the transition time, in which the language of our modern literature was being moulded into new forms. He is the earliest writer of English verse who worthily expressed in ballad form the passing incidents of the land's history in the literary language of England. His poems on the battles and the victories of Edward III. are popularly pictorial, patriotically martial, and possess qualities of selected expressiveness of phrase of which no equal examples can be quoted from the old heroic ballads. His rhyme is pretty liberally bespangled with iteration and alliteration; but it is more sustainedly refined than was usual in his time. Of himself nothing is known; of his poems ten

are extant. They treat of (1) the battle of Halidon Hill (1333); (2) the avenging of Bannockburn; (3) Edward's invasion of France (1339); (4) the sea-fight in the Swine or Zwin, in the West Scheldt (1340); (5) the siege of Tournay (1340); (6) Edward's landing at Cape la Hogue; (7) the battle of Crecy and the siege of Calais; (8) the battle of Neville's Cross (all three in 1346); (9) the sea-fight against Spain off Winchelsea (1350), and (10) the capture of Guisnes (1352). These, according to the critics, were in all likelihood composed close on the occurrence of each event, and form collectively a considerable body of contemporary verse. He is, of course, above all things national, enthusiastically patriotic, and the "noble prince," of whom he has "matter for to make," is always in the right. Here is part of the song, slightly modernized, in which he celebrates gleefully the wreaking out of England's revenge for Bannockburn:—

> "Scots out of Berwicke and of Aberdeen,
> At the Bannocksburn war ye too keen;
> There slew ye many saikless, as it was seen,
> And now has King Edward wroken it, I ween.
> It is wroken, I ween, weel worthe the while;
> War it with the Scots, for they are full of guile.
>
> "Where are the Scots of St. John's town? [Perth]
> The boast of your banner is beaten all down;
> When ye boasting will bide Sire Edward is boune
> For to kindle you care and crack your crown.
> He has cracked your crown, weel worthe the while;
> Shame betid the Scots, for they are full of guile."

The following lines exhibit the language in which he wrote:—

> "With bent bowës thai war ful bolde
> For to fell of the Frankischmen;
> Thai *gert* [gart, made] them *lig* [lie] with carës colde,
> Ful *sori* [sorry] was Sire Philip then."

When Edward II. invaded Scotland he took with him a Carmelite friar—Robert Baston, poet-laureate and public orator at Oxford, born at Nottingham, who subsequently became prior of Scarborough—whose duty was to be to record in fitting verse the triumphs of the English. He was a dramatic author, and had composed several poems on moral and religious topics, in Latin rhyming or Leonine metres, and it was hoped that the Roman lyre would give due resonance to the heroism of Edward's hosts. But the poet's hap was to be taken at Bannockburn, and entering merrily into the tragi-comedy of the situation, Bruce required him to sing as a ransom-song some "Metra de Illustri Bello de Bannockburn." He is also the author of Latin poems—"De Strivilniensi Obsidione" (The Siege of Stirling), "De Altero Scotorum Bello" (The Second Scottish War), "De Scotiæ Guerris Variis" (The various Wars of Scotland). This enforced singer of the prowess of the brave Bruce was far from being the only minstrel who rhymed the glorious acts of Robert I. Peter Fenton, a monk of Melrose Abbey, wrote, "in old rhyme like to Chaucer," "many remarkable tales" of that renowned and valiant king, the MS. of which—old, torn, and almost illegible—had been in the hands of "Patrick Gordon, gentleman," himself the author of a metrical history of Bruce, published at Dort in 1615. Fenton is not mentioned by Wynton in his chronicle, though John Barbour is named with admiration. Of Barbour's work Gordon speaks as "an old-printed book," ill-composed and unmethodical, written in an "outworn barbarous speech." The oldest edition of Barbour known is an Edinburgh one of 1616, though David Laing possessed an old small black-letter quarto, without title-page, which he assigned to 1570: and this may have been the edition to which Gordon in 1615 referred as printed. Barbour was not only the earliest great poet, but also the first distinguished historian, of his native land. Fordun, his contemporary, wrote in Latin, but Barbour employed an English almost as intelligible as that of Chaucer, although some few words, phrases, and grammatical forms belong more distinctly to the northern speech of Northumbria than to that of Mercia or the metropolis. Barbour is a Scottish poet by birth and patriotism, but he is really an English poet in speech and culture.

Another writer in the Northumbrian dialect, which prevailed in the north of England and in the Lothians, was Richard Rolle, of Hampole, near Doncaster, Yorkshire. He was born at Thornton, educated in the York Diocesan School, patronized by Thomas Neville, archdeacon of Durham, by whom he was sent to Oxford, where he made great progress, especially in theology. Sir John de Dalton gave him a cell to live in and provided for his daily wants. He was prolific of books, the busiest of religious writers among the Augustinian monks. To him we owe not only a versified, but a prose translation of the Psalms, as well as selected portions of Job done into rhyme. In an honest and earnest way, he endeavoured to set before his countrymen the need of having a "conscience void of offence towards God and towards man," and explains his purpose as a poet to be this—

> "Nam[e]ly tel lewed men of Engeland
> That can no[u]ght but Inglisc understand,
> Thar[e]for this treatise draw I wald
> In Inglisc tung that may be called.
> 'Prik of Conscience' als men may fele,
> For if a man rede and understande wele,
> And the matters thar[e]in til h[e]art wil take,
> It may his conscience tendre make."

"The Pricke of Conscience" is a poem in seven books—(1) The beginning of man's life; (2) the unsteadfastness of the world; (3) death, and why it is to be dreaded; (4) purgatory; (5) doomsday; (6) the pains of hell; (7) the joys of heaven. It was composed under the title of "Stimulus Conscientiæ" in Latin, and rewritten in English. It contains a curious compend of the theological doctrines of his time conscientiously held by the holy hermit, who wrote rather for man's good than for poetic glory; for he says—

> "For I re[c]k no[u]ght, tho[u]gh the rhyme be rude,
> If the mattere thar[e]of be gude."

Good as much of the matter is in moral aim, the rhyme is often effusively dull. Yet there are fine passages and excellent phrases in it. In these lines on the joys of heaven his power is favourably presented—

> "Alle mannere of joyes are in that state [place],
> Thare es thare ay lyfe withouten date;
> Thare es youthe ay thare withouten elde,
> Thare es alle kind of wealth ay to welde;
> Thare es rest ay thare withouten travayle,
> Thare es all gudes that never sale fayle;
> Thare es peace ay withouten of stryfe,
> Thare es alle mannere liking of lyfe;
> Thare es, withouten myrkness, lyght,
> Thare es ay daye and never nyght;
> Thare es ay sommer full bryghte to see,
> And never mare wynter in that countree.
>
> . . . .
>
> All these men may joyes of heaven call,
> Ac yet the maist sovereyn joye of all
> Is the sighte of Goddés bricht face,
> In whomme resteth all mannere grace."

Besides this ten-thousand-lined poem, Rolle produced other verses and several prose treatises on religious subjects marked by fervent fluency, if not perfect felicity of phrase.

Continuing the old metrical chronicles, in which antique Celtic traditions concerning early British history are brought into connection with the events of the passing time, we have "The Chronicle of Robert Mannyng," called also Robert de Brunne, from his birthplace Brunne or Bourne, near Market-Deeping, in Lincolnshire. The first part, taken from the "Brut" of Wace, comes down to the death of Cadwallader, the last king of the Britons, who died at Rome 703; and the second, taken chiefly from Piers or Peter de Langtoft, canon of Bridlington, Yorkshire, whose narrative he has considerably enlarged and improved, closes with the death of Edward I. 1307. Like the French, from which it is taken, Brunne's poem is composed in twelve-syllabled Alexandrines. In the prologue to the second part the rhymer thus explains his reason for writing:—

> "Lordings that be now here, gif ye will listen and lere [= learn]
> Alle the story of Englande, as Robert [Mannyng] written it fand,
> And in Inglisch has it shewed, not for the lerned but the lewd.
> For those that on this lande won, that ne Latin ne Frankye conn,

For to have solace and gamen, in fellowship when they sit samen.
And it is wisdom for to witten the state of the land, and have it written
What manner of folk first it wan, and of what kynd it first began.
And good it is for many thinges, for to hear of the deeds of kings,
Whilk were foolish, and whilk were wise, and whilk of them couth most quaintise [= policy],
And whilk did wrong and whilk did ryght, and whilk maintained peace and fight;
Of their deedes shall be my saw, in what time and of what lawe,
I shall you shew from gree to gree, sithenes the time of Sir Noë."

In 1303 Robert of Brunne translated (with many additions) William of Waddington's "Manuel des Péchés," under the title of "Handlyng Sinne," in which he illustrates by tales the "Decalogue and the Seven Deadly Sinnes," and closes with a notice of the twelve graces of thrift. It is a sort of religious morality, interpreted by stories culled from history, fiction, and real life. Our readers might like to have an opportunity of comparing some well-known passage of modern English with one of our earlier speech in 1303. We quote a verse translation, by Robert Mannyng, from 1 Cor. xiii. 4–18:—

"Charyté suffreth bothe gode and yl,
And charyté ys of rueful wyl;
Charyté hath none envye,
And charyté wyl no felunye;
Charyté ys not irus [= wrathful],
And charyté ys not coveytous;
Charyté wyl no bostful preysyng,
He wyl noughte but ryghtwys thing;
Charyté loveth no fantome,
Ne thinges that evyl may of come;
He hath no joye of wykkednes,
But loveth all that sothefast es;
Alle godenes he up bereth,
Alle he suffreth and none he dereth [= harms];
Gode hope he hath in ryghtwys thyng,
And alle he susteyneth to the endyng;
Charyté ne fayleth noughte,
Ne no thyng that wyth hym is wroughte;
When alle prephecyes are alle gone,
And all tunges are leyde ech one;
And alle craftys fordo shal be,
Then lasteth stedfast charyté;
Thus sayth Seynt Paule and moche more,
In ypystel of hys lore."

The vernacular literature of England, as an exhibition of life, is both full and true. Reason, conscience, imagination, and experience are in it woven together into a fine fabric. Of our early artists in words who held to the rhymeless alliterative verse of the Anglo-Saxon poetry, the author of the "Liber de Petro Plowman" deserves high commendation for good sense, independent thought, effective satire, and judicious reforming zeal. William de Langley was probably born at Cleobury Mortimer, in Shropshire, in 1332. He was put to school at Malvern, and was made a clerk in holy orders in Worcester. He gained a scanty and precarious living by the performance of the minor duties of a secular priest. He married early, and so closed against himself the openings to preferment in the church, and betook himself to London, where he was probably able to add to his professional means of life the hard-won eke to be gained by the copying of law-papers in the court term time. That long, lean, clerical-robed, shaven-headed form, stealing with down-bent features, but bright glowing eye, along from Westminster eastward to Cornhill, where he dwelt with Kittie, his wife, and Calotte, his daughter; or passing familiarly, on humble though holy duty bent, from Cornhill along Eastcheap, and through Cock Lane to Smithfield, Garlick Hill, or Southwark, is no ordinary man, though he is saluted by and salutes no one. He is one of the living influences of England. Though scarcely forty, resident though he is among the fripperies of Cornhill, and labouring among the poor, ill-fed, ill-clad, and wretchedly housed Londoners, he has composed and dispersed, in several elegantly-written-out copies his famous "Liber," and is engaged, under the mayoralty of John de Chichester, in revising and enlarging it. Twenty years afterwards he will remodel it once more. Having striven for a long time to live *in* and *on* London, enduring extreme poverty, some glimpses of hope lead him westward to Bristol, where, in 1399, he began his poem of "Richard the Redeless" (the unadvised), and as it would appear—from the fact that it only exists in one MS. which stops abruptly in the middle of a page—died in the course of its production, leaving it unfinished, early in 1400.

This "Liber" is divisible into two parts—viz., (1) "Piers the Plowman," and (2) "The Vision of Do-well, Do-bet, and Do-best," designed to show that Jesus is the only true Saviour of men. Of this poem there are nearly fifty MSS. extant, which vary considerably from one another, but which all, more or less accurately in the main, follow three copies, each of which is marked by distinct characteristics, and to which, by clear internal evidence, specific dates may be, with a good deal of accuracy, assigned. The first is evidently a rough draft, written rapidly as it rose in the mind of the Mercian midlander, and containing only 3567 lines; the second is carefully rewritten, under the influences of London life and opinion, and extended to nearly thrice its original length; and the third, with the increased gravity of years, is more diffuse, more subtle, and yet more thoroughly unified. The second text has been excellently edited, for educational purposes, by the Rev. W. W. Skeat, M.A., one of the most painstaking exponents of early English. He has also superintended the issue of a complete critical edition of the three MSS. for the Early English Text Society, with full and erudite notes, in four volumes. It is not only in the extent, but in the spirit of the poem that progress is observable. The character of Piers the Plowman undergoes a thorough transfiguration. In the earliest text the hero is only a high-spirited, honest, independent farmer, just in his views, Christian in his aspirations, and truthful in heart; in the later texts he is sublimed into the loftiest type of human excellence, a man in whose bodily nature the spirit of Christ dwells; and in the last it seems to be suggested that he is Christ, the Captain of salvation.

The "Vision" begins—like the "Romaunt of the Rose," Guillaume de Guileville's "Pilgrimage of Man" (part of which Chaucer has also translated in his A B C), Alain de l'Isle's "Complaint of Nature," and many other mediæval poems—with a dream. It was in merry May, when the earth forgets the winter, when the birds break the long silence of the cold months, and awake again the woodlands with the joyance of their summer songs. In a wilderness, he knew not where, the dreamer saw a field full of folk, among whom there was much to displease him. His statement of the prevalent vices of his day affords us strangely realistic insight into the life around him. In this field, situated between the Tower of Truth and the Dungeon of Care, surrounded

"With deep dyches and derk and dreadful of sight,"

there were "alle manere of men, the mean and the riche"—ploughmen, merchants, beggars, jesters, minstrels, and men of handicraft; bishops, hermits, friars, anchorites, pilgrims, and priests who had deserted their parishes; sergeants-at-law, spendthrifts, a pardoner with his indulgences, and a king to whom an angel gives good counsel; burgesses, tradesmen, field-labourers, and taverners touting for customers. A lovely lady, whose name is Holy Church, approaches him, warns him against falsehood, tells him the value of truth, and says that love is the passport to heaven. She shows him Falsehood and his companion Flattery, as well as the Lady Meed, whom Falsehood is to wed to-morrow. Simony and Civil arrange the preliminaries. Theology objects to the marriage, and all agree to go to Westminster to have the case tried. Meed has a sheriff for her steed, a "sisoure" (deputy-judge) carries Falsehood, and Guile leads the way. The king resolves to punish Falsehood, who, however, escapes and takes refuge with the friars. Meed is brought to trial before the king. She feigns holiness and is shriven, and offers to glaze a church window as a sign of her righteousness. The king proposes she should marry Conscience. He refuses, warns against Covetousness, and prophesies the coming of the day when Reason shall reign over all. The king issues a summons to Reason to attend the court. He comes with Wit and Wisdom as his servitors. Peace enters an action against Wrong. The latter knowing the complaint to be just, through

Meed's help, buys Wit and Wisdom to his side and proffers by a present to satisfy Peace. Reason will hear of no such dealing and insists on justice. The king, convinced of Reason's worth, requests him to become chief minister. At this the sleeper awakes, but soon turning his head on his pillow, gets into the field of folk again. There Reason is busily preaching repentance. Pride makes a vow of humility; Luxury resolves to be a water-drinker; Envy will think and do no more evil; Wrath, a friar, will incite to no more quarrelling; Avarice will not lie or cheat again, but learn the true meaning of restitution; Gluttony, after promising to be abstinent, on his way to church rushes into a London ale-house (of which the author gives an interior sketch in words of photographic distinctness); Sloth, a priest, who can troll out rhymes of Robin Hood more adroitly than he can pray, and poach better than preach, determines to amend his ways and live cleanly. Even Robert the robber (type of the lawless vagabonds, notorious for outrages as they raked the country) repents and promises to betake himself to right ways. All the hearers of Reason agree to go on a pilgrimage to find truth. No one knows where to go. A palmer, who had visited many a saint's shrine and had just returned from the holy sepulchre, could not tell them the way of truth. Piers the Plowman now appears. He says he can show them the way, and will when he has ploughed his half-acre. He makes his will and sets them to work. Many shirk their task, but hunger subdues them to obedience. Truth—God the Father—sends through Piers a pardon for men's sins and an invitation to his dwelling-place. A priest disputes the possibility of a pardon not countersigned by the Pope. The clash of disputation awakens William, who closes with a fine passage against indulgences and pardons, and on the infinite superiority of a life of righteousness to any such trust as they imply—

> "Forbye, I counsel alle Christians to cry 'God, mercy,'
> (And Mary, his mother, be our means betweene)
> That God give us grace here, before we go hence,
> Such workes to work while we ben here
> That, after our death-daye, Do-well rehearse
> At the day of doom, 'we did as he *hight*'" [=bade].

In the subsequent vision, which is very discursive and does not lend itself easily to analysis, Do-well represents the fear of God, Do-bet[ter] long-suffering patience, and Do-best lowliness of heart. In the first the author shows Hope and Faith passing by man, wounded on his life-way by the robber-hands of Sin; and Love, the good Samaritan, Jesus himself, in the guise of Piers the Plowman, alone having compassion and bringing salvation. Then he tells of the sufferings of Christ and the church, and sets forth in his closing dream how much requires yet to be done before conscience finds the true Piers the Plowman, the Saviour of the soul. The language is purposely antique to suit the old-fashioned versification adopted by the writer because he knew that alliteration was popular among the people. The opening lines of the prologue will show this—

> "In a *s*ómer *s*éson, when *s*óte was the *s*ónnĕ,
> I*sh*ópe me in *sh*rówdĕs as I a *sh*éepe werĕ;
> In *h*ábit as an *h*éremite, un*h*óly of wórkĕs,
> *W*ent *w*yde in this *w*órlde *w*óndres to hérĕ.
> Ac on a *M*áy *m*órnynge, on *M*álverne híllĕs,
> Me be*f*él a *f*érly of *f*áiry me thoughtĕ;
> I was *w*éary, fore*w*ándred, and *w*ént me to réstĕ
> Under a *b*róad *b*ánkĕ, by a *b*órnĕs sídĕ;
> And ás I *l*áy and *l*éned and *l*óoked in the wátrĕs
> I *sl*ómbred in a *sl*eépyng it *sw*éyned so méryĕ."

This is the Midland or Mercian dialect. It differs not only from the language of Gower and Chaucer, but from the Northumbrian of Hampole, which had become also the court-speech of Scotland, as seen in Barbour's "Bruce."

Like almost all other popular and attractive poems, it had a sort of parasitic progeny. One was published about 1394, entitled "Pierce the Ploughman's Crede." It is a short alliterative poem of 850 lines against the friars, and is due to a mind of less power and narrower notions than Langley's. The conception of the ploughman in the "Crede" is not so high nor so holy as the original. He is a somewhat harsh-minded hide-bound believer in the Creed, who shows up his own acquaintance with its tenets against the foil of the friar's ignorance of them. The author sees the ploughman in a dream, but the poetic magic of the dream does not greatly interfuse itself with the verse. Another poem, taking the use of the attraction of Langley's "Piers the Plowman," is that of "The Plowman's Tale," which appears in some editions of Chaucer's works, but is certainly—according to the opinion of the best critics—not his. It is a satire on the wealth and luxury of the dignitaries of the church, and on the corruptions of religion. A pelican represents the Anglican and a griffon the Romish Church, while the ploughman acts as umpire, and gives the palm to the pelican. Its authorship has been attributed to Thomas Brampton, a confessor belonging to the Minorite brotherhood. Whoever he was, he most probably wrote the "Crede," which, popular in MS. when written, regained a new lease of influence by its issue in 1553 by Reynold Wolfe, and its reissue in 1561 by Owen Rogers. In the latter case it was appended to a reprint, by Rogers, of "The Vision of Piers Ploughman," which had been published by Rev. Robert Crowley, under the impression that it was by the same author. About 1538 there appeared a poem printed as prose, bearing the title of "Piers Ploughman," and the lines—

> "I playne Piers, which cannot flatter,
> A plowman men me call;
> My speche is fowlle, yet mark the matter,
> How things may happe to fall."

It is a very caustic satire against Romanists; but it is not Langley's poem, the lasting power of which may be curiously illustrated by noting that in 1607 Michael Drayton, in his "Legend of the Great Cromwell," introduces, with great ingenuity and much effect, "The Morall of Contrition and the Friar," and acknowledges his indebtedness for it to "Pierce the Wise Plowman," in the twentieth passus of which it occurs. Nashe's "Pierce Pennilesse" (1592), "Piers Plainnes," by H. C. (1595), seem also to be titles suggested by it.

The popularity which Langley's poem achieved probably encouraged the conservation of the spirit and style of the alliterative verse of the early Saxons, for to this time belong "William and the Werewolf," an old English romance of unknown authorship; and "The Life of Alexander," partly translated from the Old French "Roman d'Alexandre," partly founded on a Persian poem by Simeon Seth (1070). The English romance has been attributed to Adam Davie, but there is an anonymous Scotch poem on the same subject, evidently drawn from similar sources. Davie is also said to be the author of "The Battell of Jerusalem," and there is a poem on this same subject by an unknown author, written very much in the manner of William Langley. These and other similar poetical productions may not be, strictly speaking, imitations of that author; but they probably owe their form to the example he set and the fame he gained. Of the *make* of this alliterative verse this stanza of a "Hymn to the Virgin" may be given as a specimen:—

> "Hail! be you, *M*ary, *m*other and *m*ay,
> *M*ild and *m*eek and *m*erciable;
> Hail! *f*olliche *f*ruit of soothe*f*ast *f*ay,
> Again*st* eache *st*rife *st*eadfast and *st*able!
> Hail! *s*oothefast *s*oul in each a*ss*ay,
> Under the son is none so able," &c.

John Gower was an esquire of property and education, probably of Welsh descent, though resident in middle life near Oxford, in the south-west of Kent. He has illustrated each of the great languages spoken in his day in England. The "Vox Clamantis" (Voice of one crying) is written in Latin. It was occasioned by the rising of the Commons in Kent, Essex, &c., under Jack Straw and Wat Tyler, 1381. In it he strongly stigmatizes, in seven sections, the corruptions of society, and offers good advice to the young Plantagenet king, Richard II., so ill-fated as to fall on distempered times, and so ill-fitted to manage them. The "Speculum Meditantis" (Mirror of the Meditative Man), composed in French, is lost. It seems to have dealt with the virtues and vices of men, and gained for him the characterizing epithet—

"the moral Gower." His "Confessio Amantis" (Confession of a Lover) is in octo-syllabic English verse, in which, as Warton says, Ovid's "Art of Love" is blended with the breviary. Genius, as the priest of Venus, puts the lover in the confessional, and by a set of well-devised questions, in the course of his inquisition, opportunity is given for bringing together a collection of love-tales drawn from many sources—Ovid, the Bible, Gesta Romanorum, Godfrey of Viterbo, Vincent of Beauvais, French *fabliaux*, &c.—regarding the "deadly vices seven." Some of them are coarse, even worse than coarse. Chaucer says of some of them, that they concern "unkind abominations," "of whiché cursed stories I say, fie!"

John Gower had been educated in Merton College, Oxford. He was clerk of the parish of Great Braxted, Essex, which he vacated when he married, 25th June, 1397, Agnes Groundoll, in a chapel of his own in the Priory of St. Mary Overies, Southwark, to the rebuilding of which he was a liberal contributor. In a lodging over this chapel he spent the latest years of his life. For eight years previous to his death he was blind. In his will he bequeathed his soul to God, his body to be buried in St. Mary's. His tomb in St. Saviour's Church—formerly St. Mary Overies—restored in 1832, characterizes him as "a most celebrated English poet, and to this sacred building a distinguished benefactor." A few ballads and minor poems by John Gower are extant, and have been "printed from the original MS. in the library of the Marquis of Stafford, at Trentham."

Gower wrote, though a good deal more prosaically, the same sort of southern English as Chaucer, and much in the same strain. He is not so lively and varied, not so pictorial and striking as Chaucer. He is, of course, more didactic, and therefore duller; but he is also a writer who seems to think in one language and translate into another. He does not give one the sense of ready ease and steady mastery. His works show him to be widely read, but he wanted the earnestness of nature to captivate, and the healthiness of spirit to entrance. He dissects and dissertates rather than paints and points a moral. His mind was more under French than Italian influences. He is cold and prosy, tedious and trying; yet he had the power of gratifying the age in which he lived, and the honour of being a friend of Chaucer, though of his humour, love of nature, and passionate fire he had scarcely any. Shakspeare took from his repertory the materials for "Pericles," and as "the ancient Gower" brings him on the stage as prologue of that play. We may quote, as illustrative of his language the last lines of Gower's "Confessio Amantis."

> Thilké love, which that is
> Within a manne's herté affirmed
> And stands of charité confirmed,
> Such love is goodly for to have,
> Such lové may the body save,
> Such lové may the sole amende,
> The highé God such love us send
> Forth with the remenaunt of grace
> So that above in thilké place
> Where resteth love and alle peace
> Our joié may be endéless."

John Barbour, author of "The Book of the Gestes of King Robert Bruce," wrote his historic epic of the chivalrous Scottish monarch, who in an age of warlike valour was esteemed a very perfect model of heroic knightliness and statesmanlike wisdom. Of this author Blind Harry says—

> "Master Barbour, whilk was a worthie clerke,
> He said *The Bruce* among his other werke."

This poem was partly written during the reign of the hero's grandson, Robert II. That king and the minstrel were what is called in Scotland "ae year's bairns," both having been born in 1316, when the laurels of the victor at Bannockburn were fresh and green, and the tales of his prowess were told around the fire in the winter night, by eye-witnesses and fellow-fighters,* and outvied in their attractiveness the romantic legends of love and war which had charmed the imagination of an older time. With the quick eagerness of a ready-witted boy, Barbour heard the strange story of "good king Robert," who died at Cardross, 7th June, 1329, when his future eulogist was a schoolboy. He may have been the scion of a household retainer of Bruce, when Lord of Annandale, among whose charters, granted when king, there is one gifting "the lands of the toft in Moffat, with two adjacent oxgates of land formerly held by William called Inglis, to Adae Barbitonsori"—Adam Barbour. Like all lads inclined to learning then, he studied for the church. In 1356, at the age of forty, he was, by David II., appointed archdeacon of Aberdeen. On the application of the Scottish sovereign to Edward III., August, 1357, permission was granted to him to visit Oxford, with three scholars—to whom he probably acted as tutor—in his company, and in September of the same year he was nominated one of the commissioners to deliberate on the ransom of King David, then a prisoner in England. On 6th November, 1364, "a safe-conduct" authorized Barbour to pass through England, attended by four horsemen, to study at Oxford or elsewhere that he thought fit. Edward granted him permission, 16th October, 1365, to travel through England with six companions on his way to St. Denis—then the mausoleum of the kings of France—and other holy places. He was allowed again, 30th November, 1368, to proceed, duly attended, to France for purposes of study. All these well-authenticated documents show his devotion to learning, his influence, and the trust reposed in him. On 18th February, 1373–74, he was appointed one of the auditors of the national exchequer. He held also the office of clerk of probate in the household of the king. His name appears in the accounts of the great chamberlain of Scotland as the receiver of two pensions—an annuity of ten pounds, payable for life, out of the customs of Aberdeen, and a perpetual pension disposable in mortmain of twenty shillings from the royal rents. He died, as the chartularies of Aberdeen show, in 1396, having reached the venerable age of eighty.

Besides his great metrical historical poem, Barbour was known, on the authority of Wynton, to have "mayd in-til a genealogy recht wele" a digested record of the Scottish kings from the fabulous Brutus of Troy—of whom Wace and Layamon had sung—to the reign of his patron Robert II. Dr. Jamieson inferred that Barbour in the line

> "The Broite thairoff bairis wytnes"

alluded to a previously written poem of his own. This conjecture has to a considerable extent been verified. Mr. Henry Bradshaw, librarian of the University of Cambridge, in 1866 announced the discovery in a Scotch MS. of Lydgate's Troy Book, formerly in the Duke of Lauderdale's collection, that the copyist had used two versions of the "Historia Trojana" of Guido delle Colonne, which differed in metre and dialect, and had, when he turned from one to the other noted respectively, "Here endys barbour and begynnys the monk," and "Here endys the monk and begynnys barbour." Thus the first English versifier of Colonne's Trojan history was found to be Barbour, and 2200 lines of his translation have been recovered. To this we must add 40,000 lines of a collection of (fifty) "Lives of the Saints," from the same pen.

The metrical chronicle of "The Bruce" contains about 12,500 rhymed octo-syllabics, and is, notwithstanding the short, quick-pacing lines, perhaps, on the whole, the best heroic poem extant in English, if not in any literature, for indeed in heroic poetry few works of extraordinary merit have as yet been produced. It requires a unique connected series of great actions, intermingled with romantic incidents and exploits, variety of detail and intensity of interest, to supply the groundwork of a heroic poem, while fire, spirit, and native power—clear, vigorous, and choice expression—are essential to the execution of it. The work must neither be fulsome nor tedious; it must adhere to truth, yet stimulate to admiration; it must be full of force and fair of form; possessed of extrinsic interest and intrinsic worth. Of such sort is the poem in which Barbour sets forth the doughty deeds of Sir James Douglas, Randolph earl of Moray, and *the* Bruce.

* For instance, he gives not only "tale, but talesman," in the following terms in his great poem—

> "A knycht that then was in this rowte,
> Worthie and wycht, stalwart and stout,
> Curteous and fayr and of gude fame,
> Syr Alane of Cathkert by name,
> *Tauld me this tale* as I shall tell."

Here is the Archdeacon of Aberdeen's idea of historic poetry:—

"Stories to read are delectable,
Suppose that they be nought but fable;
Then should stories that soothfast were,
An they were said in good mannére,
Have double pleasaunce in the hearing;
The first pleasaunce is the *carping* [= telling]
And the other the soothfastness,
That shews the thing right as it wes;
And such things that are likand
Til manne's hearing are pleasand.
Therefore I woulde fain sette my will,
Give my witte might suffice, theretill,
To put in writ a soothfast story,
That it lest aye forth in memóry,
So that na time of length it let,
Or gar it wholly be forget.
For auld stories that men reads,
Representés to them the deeds
Of stalwart folks, that livit are [= early],
Right as they then in presence were.
And certes, they should well have prize
That in their time were wight and wise
And led their life in great travail,
And oft in hard stour of battaile,
Won right great price of chivalry
And war voidit of cowardry,
As was King Robert of Scotland,
That hardy was of heart and hand;
And good Sir James of Douglas,
That, in his time, so worthie was
That of his price and his bounté
In far lands renowned was he.
Of them I think this book to ma [= make].
Now God give grace that I may sae
Treat it and bring it until ending
That I say nought but soothfast thing."

Justice cannot be done to Barbour's poem by quotation. But if any quotation is made, that which contains the patriotic keynote of the whole must not be omitted:—

"Ah! Freedom is a noble thing!
Freedom maks man to haiff lyking;
Freedom all solace to man gives.
He lives at ease that freely lives!
A noble harte may haiff nane ease,
Ne else nocht that may hym please
Gif Freedom failyth; for free lyking
Is yearned [for] owre all othir thing.
Na he, that aye has livyt free
May nocht know well the propertye,
The angyr, na the wrechyt doom
That is couplyt to foule thraldome.
But gyf he had assayit it,
Than, alle *perquer* [*per cœur* = by heart], he should it wyt,
And should think Freedom more to pryse
Than alle the gold in warld that ys."

Of his power and felicity of scenic description, the following lines may be given as a sample:—

"This was in Ver, when Winter-tide
With his blastes hideous to bide,
Was overdriven and birdés smale
As turtle-[dove] and nightingale
Beganne rycht sorrily to syng,
And for to mak in thair singyng
Sweeté notes and soundys *ser* [many]
And melodys pleasand to hear,
And the trees beganne to ma
Burgeous and brycht bloomys alsa,
To win the healing of their *hewid* [head]
That wiked winter had them *rewid*" [reft].

But Bannockburn brings the brave blood fresh from the heart and tingling into his finger-tips. His pen quickens with the clash of sword, and tramp of troops stirs his spirit. He may now give us a few touches of his war-verse.

"The Scottishmen commonally
Kneelit all down, to God to pray.
And a short prayér there made they
To God, to help them in that fight.
And when the English king had sight
Of them kneeling, he said in hyght,
'Yon folk kneel for to ask mercy!'
Sir Ingram sayd—'Ye say sooth now—
They ask mercy, but not of you;
For their trespas to God they cry.
I tell you one thing sickerly,
That yon men will win or die;
For doubt of death they shall not flee.'
'Now be it so then,' said the king,
And then—*but* [= without] longer delaying,
They gart tramp to th' assembly.
On either side men might them see,
Many a wycht man and worthy,
Ready to do chivalarie.
Thus were they boun on either side,
And Englishmen, with mickle pride,
That were intill their avaward
To the battaile that Sir Edward
Governt and led, held straight their way,
The horse with spurs hastenéd they,
And prickt upon them sturdily;
And they met them richt hardily,
Sae that at their assembly there
Sich a frushing of spears were
That far away men micht it hear
That at that meeting farouten were;
That steedes stickit many a ane,
And mony gude men borne down and slain . .
They dang ane other with weapons sair.
Some of the horse that stickit were
Rushit and reelit richt rudely. . . . .
That time ther three battles were
All side by side fechting weel near.
There micht men hear mony a dint,
And weapons upon armour stint,
And see tumble knechts and steedes,
And mony richt and royal weedes
Defoulit foully under feet.
Some held on loft, some tint their seat.
A lang time thus fechting they were,
That men nae noise micht hear ther;
Men heard nought but groans and dints,
That flew fire as men flays on flints;
They focht ilk ane sae eagerly
That they made nae noise nore cry,
But dang ane other at their micht
With weapons that were burnisht bricht. . . .
Almighty God, how doughtilly
Sir Edward the Bruce and his men
Among his faes conteinit them then,
Fechting in sae gude covine,
Sae hardy, worthy, and sae fine! . . .
There micht men hear ensignes cry,
'On them! on them!! on them!!! they fail.'
With that, sae hard they 'gan assail,
And slew all that they micht owerta [ke];
And the Scottis archers alsa
Shot among them sae deliverly,
Engrieving them so greatumly,
That what for them that with them focht,
That sae great routs to them wrocht,
And pressit them ful eagerly.
And what for arrows that fellounly,
Many great wonders gan them ma [ke],
And slew fast of their hors alsa,
That they *vandyst* [= yielded] a little way,
They drad so greatly them to dey
That their covine was wer and wer;
For they that fechting with them were
Set hardiment, and strength and will,
And heart and courage als, theretill,
And all their main and all their micht,
To put them fully to the flicht."

Here, surely, there is a Homeric cloud of war-dust, a clashing of angry swords, a rush of heroes on horseback, and a general noise of battle, such as betoken a spirit of enjoyment of fierce fray and fight-gained freedom considerably above the average of those who wield that instrument which, as Lord Lytton said, is "mightier than the sword"—a pen.

SECTION II.—THE BEGINNINGS OF ENGLISH PROSE—MANDEVILLE, TREVISA, WYCLIFFE, AND CHAUCER.

Communicativeness is a characteristic of man. Social life requires the receiving, the registering, and the transferring of information. Conversation is a necessity, a pleasure, and an art. When speech is regarded as an artistic product it presents itself as verse (Lat. *versus*, a turning); but when it is merely employed as a medium for the exchange of thought, and goes straight forward to that end, it is regarded only as prose (Lat. *prosa*, direct, straight). Early writers of course preferred the artistic forms of speech, and hence literature almost always attracts our attention in its art-form as poetry. Some time must elapse before the matter to be communicated, and the manner of its communication, become of sufficient importance to be registered, and then the statements made are usually of only temporary value, or do not otherwise demand aught else than immediate attention. Literature, as a reproduction of spoken speech in its straightforward inartistic form, has generally an object to obtain, and that gained, its office is ended. Man, however, enjoys the neat, pleasing niceties of art when they can be had. Speech, necessity though it is, is adorned; style distinguishes some speakers from others, and prose becomes rhetorical. Speech is contented with mechanic collocation of words; in literature the syntax aims at being organic. The mere retail of words may be transacted with loose and ready counters, but the commerce of thought requires minted coin or certified exchange-notes. The man who writes feels himself almost inevitably impelled to give an artistic form to his composition; and being, in general, free from the outward disturbing influences which affect those who speak in the presence and exposed to the hurry, fret, or interest of hearers, he is expected to give care and consideration to what he writes. Our earlier prose writers imitated, as far as they could, the spoken language of their day; but they could scarcely divest themselves of the feeling that writing is a much more formal art than speech.

The beginnings of English prose are difficult to determine. Professor Edward Arber gives as the earliest of his English reprints, "A marvelous Revelation that was shewed of Almighty God by St. Nicholas to a Monk of Evesham in 1186," though he states that its orthography belongs to about 1410. He says of it, "The essence of the story is as old as it professes to be. It is very devoutly written, and contains a curious vision of purgatory. The writer is a prototype of Bunyan; and his description of the gate in the crystal wall of heaven, and of the solemn and marvellously sweet peal of the bells of heaven that came to him through it, is very beautiful." George Saintsbury is contented to commence with Sir Thomas Malory, whose "Book of the noble Hystoryes of Kyng Arthur, and of Certayn of his Knyghts, reduced into Englysche," was finished in 1469–70. The monk had the precedency of Malory as to the printing of his book by four years, as the "Revelation" was published by William de Maclinia in 1485, and the "Kyng Arthur" by William Caxton in 1489. Malory's English is masterly, earnest, and flowing, sometimes adorned with beauty and animated by eloquence; still it is really "an adaptation from French originals," and the writer, according to Leland, was a Welshman. Though the material of his "Histories" has been incorporated into literature, we do not feel inclined to give him quite the first place; for that would compel us to omit from our catalogue not only Mandeville and Trevisa, but Wycliffe and Chaucer, with whose names the earlier pages of our English prose are richly adorned.

Chronicles at first seem to require little art, and are mere records of events. Gradually they acquire the form and aim at the dignity of history. The popularity of narratives in oral form suggests the securing of them in writing, and in good time men feel that they have the art and faculty of narrating their experiences and ideas in such a manner as to delight and instruct others. Among the earliest writers of *literate* prose was Sir John de Mandeville. "The Voyaige and Travaile, which treateth of the waye to the Hierusalem, and of the Marvayles of Inde, and other islands and countries," of which he was the author, was written in Latin, in French, and in vulgar English, that "everie man of his nacioun" might read it. "I, John Mandeville, Knight," he tells us, "was born in the town of St. Albans, passed the sea in the year of our Lord Jesus Christ, 1322, on the day of St. Michael (29th September), and hitherto have been a long time over the sea, and have gone through many divers lands and many provinces, kingdoms, and isles." He returned to England, 1356, and died at Liège, 1371. This strange *mélange* of marvellous legends of the middle ages was printed in Italian, at Milan, in 1480. In England it was exceedingly popular, abounding as it did in curious stories, gratifying to the credulous, and exciting in their interest. Having passed through Persia, Armenia, Libya, Chaldæa, Ethiopia, the Holy Places, &c., as an adventurer and an inquirer, he records the results of his researches, alleging as his reason that "things passed out of long time from a man's mind or from his sight, turn soon into forgetting; because that the mind of man ne may not ben comprehended or withholden for the frialty of mankind." "The Soudan of Egypt," he says, "would have married me full highly to a great prince's daughter, if I would have forsaken my law and my belief." He had gone to Pekin, and it is worthy of notice that he states, "I tell you certainly that men may go all round the world, as well under as above, and return to their country, if they had company, shipping, and guides." His collection of traveller's tales is extensive, and they are well told. "There are," T. L. Kington Oliphant says, "barely more than fifty obsolete English words in the whole of Mandeville's book, though it extends over 316 printed pages." It may represent to us the English speech used at court in the latter days of Edward III. In his day Latin was the language of business, French of society, and English of the common people. He is often characterized as "the father of Early English prose-writing."

John de Trevisa, a Cornishman, who, according to Caxton, made an English version of the Bible, of which, however, no part is extant, was a copious translator from mediæval Latin into the folk-speech of his age. He was chaplain to Thomas Lord Berkeley, at whose request he translated Ralph Higden's "Polychronicon," which he finished in 1387, and which Caxton printed "a lytel embelysshed fro the olde makying" in 1482. He informs us that while he was writing in Gloucester, Latin had begun to be taught through English rather than French, which, however, though "a come-ling" from another land, was, he says, well-spoken in England prior to the great plague in 1349. Of the state of English as a tongue he gives us this account:—

> "The forseyde Saxon tongue ys deled a [divided into] three, and ys abyde scarslych with few uplondysch men, and ys grete wonder; for men of the Est with men of the West, as hyt were under the same partye of hevene, accordyth more in sonnyng of speche then men of the North with men of the South; therefore hyt ys that Merci, that buth [are] men of myddel Engelond, as hyt were parteners of the endes, understondeth better the syde languages Northeron and Southeron then Northeron or Southeron understondeth eyther other."

John Wycliffe, who is often spoken of as "the morning star of the English Reformation," provided the laity of his native land with a translation of the entire Scriptures, not done by himself alone, but with the good help of many who sympathized with his design. During a quarter of a century, under his superintendence, the work proceeded. What are known as "the Hatton Gospels," in the Old Southern English of Ethelred's time, were the latest versions of Scripture put forth in England prior to Wycliffe's effort. The Wars of the Albigenses and the Lateran Councils hindered any similar attempts for nearly two centuries. Free and often rhyming paraphrases of several books of the Bible had been made, and a complete Psalter was among the possessions of the English-speaking races; but Wycliffe marvellously enriched the language of life by bringing together the necessarily large and varied phraseology of Scripture within reach of the common people. This holy literature contained, in a body, a soul of wisdom of the highest value; for it tasked the genius and patience of the gifted few to bring the choicest and most select elements of the rude but ripening English vocabulary into this book, which from its nature was sure to be studied,

and from its fitness for man's state certain to be employed and referred to in the more earnest conversations of men. This version, clear, homely, and vernacular in its style, was circulated in scores of manuscripts copied by faithful and enthusiastic Lollards desirous of spreading the light of life and love among their kinsfolk. The Duke of Lancaster, John of Gaunt, in Parliament in the time of Richard II., says, "We will not be [the] refuse of all other nacions; for sythenes they have Goddes lawe which is the lawe of owre belefe in their owne language, we will have owres in Englische whosoever say naye!" and he expressed the mind of the people in these words. Wycliffe was born about 1324, at the village of Wycliffe, near Richmond, in Yorkshire. He was warden of Balliol College, Oxford, 1361. Thence he went to the rectory of Fylingham, in Lincolnshire, to which his college presented him, and shortly afterwards took the degree of D.D. In 1368 he removed to Lugershill, Buckingham, and in 1374, on a crown-presentation, he exchanged this for the living of Lutterworth, Leicestershire. In 1376 he was arraigned as a heretic, and commanded to forbear teaching or preaching such doctrines as he sets forth in his essay on "The Truth and Meaning of the Scriptures," affirming the fulness and clearness of the Scriptures alone as a rule of faith, and in "Wycliffe's Wicket," a treatise on the sacrament. The monks procured a papal injunction that he should be silenced. When, in 1378, he appeared at Lambeth Palace, the court and the people alike intervened to stay the bishop's proceedings. He was a schoolman, expert as a logician, and notable as a systemizer. He wrote many Latin tractates; but after 1381 he betook himself mainly to the use of the English tongue. He was banished from the university in 1382; and in 1384, under summons to appear before the Pope, he entered, by death, into a higher presence and impartial judgment, 31st December. The Convocation at Oxford, in 1408, prohibited the using or diffusing of his version of the Scriptures; at the Council of Constance his doctrines were denounced as heretical, and his bones were ordered to be exhumed and burned. This was done, and his ashes were cast into the small stream Swift, which passed his vicarage. This took them, as Thomas Fuller says, "into the Avon, Avon into the Severn, Severn into the narrow seas, they into the main ocean, and thus the ashes of Wycliffe are the emblems of his doctrine, which is now dispersed all the world over."

Few laymen wrote English prose between the age of Alfred and the times of Wycliffe. Both Mandeville and Chaucer in the latter period considerably increased the wealth of words, belonging to this world's ways, brought into use among men. Chaucer's English prose style is easy and clear. His vocabulary is extensive and expressive. The impress of his genius is as vividly impressed on his prose as his poetry. Two of his "Canterbury Tales"—that of "Melibœus" and of the "Parson"—are in prose, and afford favourable specimens of his skill and power in writing. He is author also of a "Treatise on the Astrolabe"—compiled "for the use of his son Lewis, at that time a student of the University of Oxford." It was in five parts, of which only two remain. Its simple, loving, earnest language addressed to a clever boy, to whom he had given as a present the instrument then used for taking the heights of stars, shows how masterly his grasp of English was, and his confidence in its power to convey thought educatively into the mind by its means. "If it so be," he says, "that I show thee in my little English as true conclusions touching this matter, and not only as true, but as many and subtle conclusions as be showed in Latin in any common treatise on the astrolabe, con me the more thank; and pray God save the king that is lord of *this* language." He tells us of himself

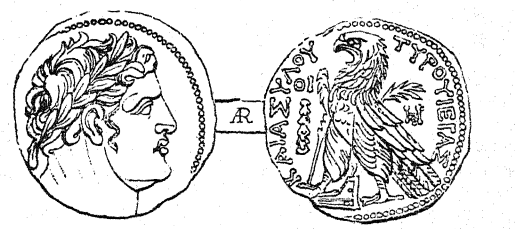
"He has in prose translated Boëce."

His version of Boethius' "Consolations of Philosophy"—which King Alfred before and Queen Elizabeth after him, each translated—is much less happy in its style than the "Testament of Love," which, about 1389, for his own consolation in adversity, he wrote "in soche wordes as we learneden of our dame's tongue." His consolation is religion; divine love comforts him. In its three books he gives many invaluable spiritual lessons regarding the comfort to be found in true faith and holy obedience; the being, greatness, and glory of God, and the blessedness of those who gain His favour, and on the necessity of subduing our own will that we may learn both to will and to do of God's good pleasure, and so be made sharers in God's divine "testament of love." Courtier, traveller, place-seeker and pensioner, ambassador, philosopher and poet, Chaucer's is the greatest name even in prose of which the long, eventful, and chivalric reign of Edward III. can boast.

HISTORY.—CHAPTER IV.

FOURTH AND FIFTH ERAS OF ROMAN HISTORY.

THE real history of Rome, unmixed with mythological or traditionary legends, extends from about the commencement of the first Punic War till the date of the admission of the Italians to the full citizenship of Rome. Rome—a state with magistrates elected for short statutory periods by the free citizens—was sovereign over all the other Italian states. These had no voice, no control over, the general government; they had no civil rights, no civil privileges. The Romans were, from their peculiar national character, eminently tyrannical. They had commenced their career as a warrior race, and this



Coin of Tyre.

character had been confirmed by circumstances. With them virtue and bravery were designated by the same word. The sceptre of Rome was literally a rod of iron. Its despotism, exercised on all its subjects alike, was employed upon people of widely varying characters. The Greeks in the south of Italy, enervated and effeminate, gave little trouble; but the Latin, Oscan, and Etruscan tribes, educated in the same school as the Romans themselves, had much of their own proud and unbending character. They were not naturally inclined to acquiesce in a state of political vassalage; and thus predisposed, the exactions of the Romans furnished them incessantly with valid causes of discontent. These were the sources of those internal struggles which tasked the energies and filled the thoughts of the men of Italy, of which it will therefore be necessary to present a brief outline.

The first state with which Rome came into serious collision, after the subjugation of the whole of Italy, was Carthage. The treaty entered into between these two states has already been mentioned. From its terms alone some faint idea may be formed of the power and ambition of Carthage even at that early period. The Carthaginian state resembled Rome in this, that over its wide extent the sovereign sway was exercised by the elective magistrates of one city. Carthage was originally a colony from Tyre, inhabited by a Semitic race. It was, and had long been, an independent self-governing state. Carthage stood on an expanse nearly square, bounded to the north and east by the sea, to the south by the Lake of Tunis, and to the west by a broken desert country. Two isolated eminences within this space were occupied by two settlements—the one termed Magor or Magalia, the other Byrsa. Both claimed to have been Phœnician settlements. The claim is corroborated in the case of the latter by the name *Byrsa*, which seems to be the same with the Phœnician *Bosra*, a fort. The designation of the former seems to be the appellation used by the aboriginal Libyans to designate a collection of dwellings. A third settlement, of later date, was known by the name Katum or Cothen, indicating a cut or excavation, and seems to have been at the harbour. All these were included within the walls of Carthage, separate in territory, with exclusive fortifications, and seemingly with

exclusive jurisdictions. The executive, and apparently, the judicial, authority reposed at Carthage in the hands of two magistrates—elected, it does not very clearly appear by whom or for what term—whose title is identical with that rendered in our version of the Holy Scriptures by the word "judges." Carthage had, like other early nations, recourse to the practice of colonization. It may have been driven to this by the necessity of getting rid of a redundant population; but a more immediate object seems to have been to render these colonies subservient to the mercantile enterprise of Carthage, as those of Rome were to its thirst for extended territory. The earlier Carthaginian colonies extended south and east along the coast of Africa towards the Syrtis, where they were arrested in their progress by the Grecian and Egyptian powers. They next stretched along the western coast of North Africa at least as far as the Straits of Gibraltar. The coasts of Spain had long been known as an advantageous site of traffic to the Phœnicians of Syria. The Carthaginians did not fail to settle colonies there also. They formed settlements in Sicily, and even, for a short time, in the islands of the Tyrrhenian Sea. All these colonies were kept in intimate relation with and dependence upon the parent state. They formed a chain of forts along a line of Mediterranean coast which hemmed in the domain of Italy. The natives of the lands in which they were planted were taken into alliance with Carthage. The governmental armies were composed of Carthaginian citizens, the contingents of the subdued Libyan tribes, and mercenary troops hired from the neighbouring independent sovereigns. The commercial pursuits of the Carthaginians furnished them with a large and powerful navy, and with the means of keeping afoot huge armies. They were more advanced in civilization and more wealthy than the Romans; they had a literature of their own, and were not unacquainted with that of Greece. But the Carthaginians had not the healthy element of a free plebeian *caste* to keep them in check. Wanting this they had no infantry such as formed the strength of the Roman army. Again, the peculiar commerce they engaged in was of a half-huxter, half-pirate kind, which contaminated more or less all classes of the citizens. The Romans were so struck with this that "Punic faith" passed with them into a proverb. The territory of the Romans was compact and central; from it an attack could be directed with ease against any point of the long line of Carthaginian coast.

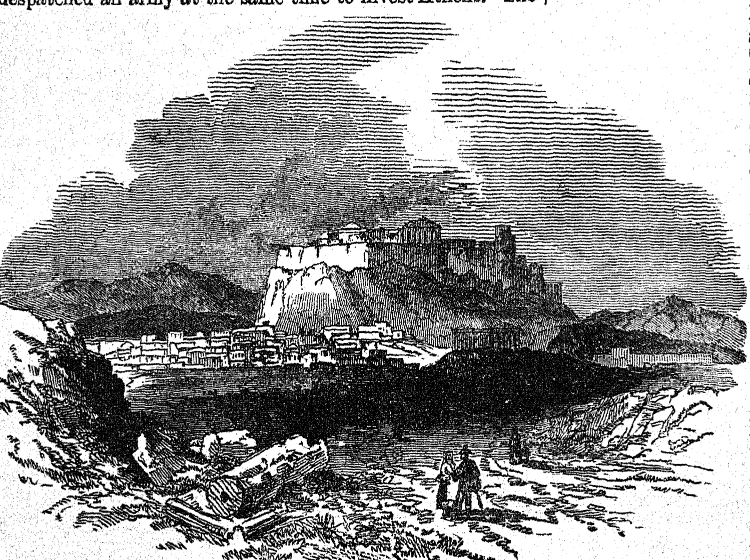
Each of these states having cleared away all rivals on the ground which each occupied, came into direct contact along the greater portion of their respective frontiers. The small but fertile territories of Sicily, Sardinia, and Corsica served rather as incitements and pretexts for quarrel, than as peace-preserving intervening objects. Neither could endure in its vicinity an independent and equally powerful state. The might and the ambition of the two states determined that there should be war, and that that war could only terminate with the final subjection of one of them. Three wars, with short breathing times of peace, between Rome and Carthage, occupied the years B.C. 264–241, 218–202, and 149–146. In the first, Rome acquired a naval force—a warlike marine, and knowledge of naval tactics. In the second, the Roman generals learned to apply the principles of war to the overthrow of extended empires. Their military knowledge ceased to be mere matter of discipline, and was advanced to the dignity of tactics. In the third, Carthage was destroyed, and the plough passed over her ruins. Rome inherited her ascendency among the Celtic tribes of Spain; and, after half a century of interim arrangements—giving rise to constant battles and short-lived local tyrannies—the greater portion of Northern Africa was made a dependency of Rome.

Rome's external policy was not limited to this protracted struggle with Carthage. The Persian monarchy—erected on the ruins of preceding dynasties—extended its sway over Asia Minor, Western Persia, Mesopotamia, Syria, and Egypt. All these countries were inhabited by tribes retaining their original language, customs, religion, laws, and military organization. But they had no control over, or part in, their civil government. That was exercised by a hierarchy of satraps, appointed by, and dependent upon, the one possessor of the Persian throne. There was immense variety of social institutions within this empire, but for purposes of external aggression it could be made to move as one mass. This power was repeatedly experienced by the Greeks. They inhabited the continent between the Gulf of Thessalonica and the Adriatic Sea—the peninsula now called the Morea—and the islands with which the eastern extremity of the Mediterranean is studded. Their colonies extended along the shores of Asia Minor, Thrace, the coasts of the Black Sea, the south of Italy, Sicily, and the coasts of north Africa between Egypt and the Carthaginian territories. None of these parent states attained such an ascendency over the others as Rome and Carthage achieved. Language, customs, relationship, kept up a kind of cohesion among the Greeks. But there was no permanent organized union among them. The development of the individual character was more an aim in Grecian states than the development of the social disposition. This was the case also in the relations of these states with each other. The wars between the Persian Empire and the Greek people showed how much more important they thought the development of the free energies of the individual was, than the mere conventional fitting of individuals into certain places in society. Twice the Persian monarchs hurled their organized masses against Greece, and twice the spontaneous alliance of Greek freemen shattered and drove back their hordes of slaves. Circumstances for a short time united the whole power of Central Greece in the hands of Alexander; and the brief career of that monarch was sufficient to overthrow the Persian dynasty. Immediately upon his death Greece was again broken up; but the Greeks still maintained the sovereignty of Asia. Eastern Europe, Western Asia, and Egypt were, from the death of Alexander until their conquest by the Romans, the seat of Grecian power. Myriads of peoples were scattered over this space, but Grecian rulers, Grecian arts, literature, and science, predominated everywhere. Western Asia was shared between the Greek principalities of Pergamus and Syria, but even inner Bactria had its Greek sovereigns. Egypt was a Greek principality—so was Macedonia, including Epirus, Thessaly, and Greece, to the Isthmus of Corinth. The Thebans and Athenians remained independent states. On the north side of the Gulf of Corinth there was a confederacy of free cities, named the Ætolian League; on the south another, including in its palmy days Corinth and Megara, called the Achæan League. Cyrene, between Carthage and Egypt, and most frequently subject to the latter, was a Greek state. The south of Italy was mainly peopled with Greeks; so was Sicily. Even at the bight of the Gulf of Lyons there was a Greek city—Massilia, now Marseilles.

Rome was for a moment brought into contact with a Grecian state beyond the limits of Italy, when the Tarentines called in the assistance of Pyrrhus. The attention of the civilized Greeks, however, had been directed to the energetic youth of Rome long before any Grecian state measured swords with it. Aristotle mentions its institutions as curious and worthy of study. There is something interesting about this first appearance of the Romans among the Greeks. In 519, during the interval between the first and second Punic Wars, the temple of Janus at Rome was shut, indicating that the republic was at peace with all the world—rather a rare occurrence in its quarrelsome annals. The Illyrians had become a considerable nation. Having convenient harbours and retreats for shipping, they carried on a piratical war against all their neighbours; and it thus happened that they committed depredations upon some Italian traders, the subjects of Rome, entitled to Latin protection. The Romans claimed redress, and were replied to, on the part of the Illyrian queen, that, the seas being open, no one could answer for what was transacted there; and that it never was the custom of kings to debar their subjects from what they could seize upon by their valour. The Roman envoy, with characteristic pride, stated that his country was regulated by different maxims — that there, the crimes of private persons were restrained by the state, and that Rome would reform the practices of kings in this particular. The queen, incensed, regarding these words as an insult to herself, had the Roman deputy waylaid and murdered. In revenge for this outrage, the Romans made war on the queen; obliged her to offer

reparation for the injuries she had done to the traders of Italy, to evacuate all the towns she had occupied on the coast, to restrain her subjects in the use of armed ships, and to forbid them to navigate the Ionian Sea with more than two vessels in company. The Romans, desirous of having their conduct approved of by other nations, sent a copy of this treaty, with an exposition of the motives which had induced them to cross the Adriatic, to the Achæan League. They made a like communication at Athens and Corinth. In consideration of the signal service they had performed against the Illyrians—then reputed the common enemy of civilized nations—they had an honorary place assigned them at the Isthmian games, and in this manner the Romans made their first appearance in the councils of Greece. The Greeks were struck with the energy of the Romans. The imaginative Greeks attributed high intellectual and moral excellence to this rude energy. They persuaded themselves that the Roman rusticity was, in reality, the result of philosophy. They set up the Romans as idols for Greece to worship; and discovered in time that animated idols are more exorbitant than idols of wood, stone, or metal.

Their character being thus established in Greece, the Romans waited for an opportunity to advantage themselves by it. Towards the close of the second Punic War, Philip, king of Macedonia, sent auxiliaries to the Carthaginians. Some of these were taken prisoners at the battle of Zama. Philip demanded their liberation in rather arrogant terms. The Roman Senate answered that he appeared to desire a war, and he should have it. Philip, however, had been appointed head of the Achæan League, and was using the influence this situation gave him to make himself absolute master of Greece. He laid siege to Abydos in person, and despatched an army at the same time to invest Athens. The



Athens.

Athenians sent envoys to Rome to sue for protection. "It is no longer a question," said the Consul Sulpicius, in his harangue to the people, "whether you will have a war with Philip, but whether you will have that war in Macedonia or in Italy. If you stay until Philip has taken Athens, as Hannibal took Saguntum, you may then see him arrive in Italy, not after a march of five months, and after the passage of tremendous mountains, but after a voyage of five days from his embarkation at Corinth." By this argument the reluctant people were induced to engage in a new war before the old was well terminated. It lasted five years. The Romans obliged the King of Macedonia to withdraw his garrisons from every fortress in Greece, and to leave every Grecian city, whether of Europe or Asia, to the full enjoyment of its own laws. They made him surrender all his ships of war but one galley, and reduce his ordinary military establishment to 500 men. They forbade entirely the use of elephants. They demanded to have the Roman captives restored, deserters delivered up, and a sum of 1000 talents to reimburse the expense of the war. The Romans thus at once humbled and weakened the Macedonian state; they left Greece split up, as before, into a number of weak jealous republics; they increased the favourable estimate of their character; and they accustomed the Greeks to look up to them as protectors—

Grecian Games.

that is, as superiors. To impart greater solemnity to the service they had done to the Grecian states, they had it proclaimed at the Isthmus of Corinth, where people met from every part of Greece to solemnize the ordinary games. Their flatterers or their dupes extolled them as the restorers of freedom to mankind. These ceremonies were performed in the year of the city 557.

As usual one war led to another. Antiochus, the Greek king of Syria, advanced to the assistance of Philip when it was too late. The Roman deputies charged with the execution of the recent treaty, encountered Antiochus at Lysimachia, a city of Asia Minor. They remonstrated against some of his proceedings in that country. "The Romans," they said, "had not rescued the Greeks from Philip to deliver them over to Antiochus." That monarch replied with haughtiness; but as his attention was required at the moment in Egypt and that of the Romans in Spain, no immediate hostilities ensued. The Romans, however, made the necessity for watching Antiochus a pretext for retaining hold of several Greek cities, and they availed themselves of the possession of these cities to take part in the politics of the Peloponnesus. Hannibal, about this time an exile from his native land, took refuge at the court of Antiochus. This circumstance augmented the vigilance with which the Romans watched that monarch. The result was a war between Antiochus and Rome, in which the Grecian states took different sides. In the year of the city 562, a Roman army for the first time set foot in Asia. Still the Romans preserved the appearance of magnanimity. Upon the defeat of Antiochus large territories were taken from his kingdom, but they were shared between the Greek king of Pergamus and the Greek republic of Rhodes. Some of the Asiatic cities were restored to independence. The Romans contented themselves with the reimbursement of their charges during the war. Thus they gratified ambition and cupidity, multiplied and weakened the independent states, accustomed the nations to regard them as umpires of justice, and familiarized men with the notion that the Romans had the right as well as the power to gift away kingdoms and provinces.

The time had come for further steps of aggrandizement. A quarrel with the King of Macedonia led to a war in which Illyricum was involved. It terminated favourably for the Romans. They suppressed these kingdoms, and organized the territories over which their sway had extended into seven republics, in which government should be administered by councils and magistrates chosen by the people. These republics, nominally independent, but really organized under fifteen Roman commissioners appointed for an indefinite period, and in presence of a Roman army and general, could not become permanent. In the Macedonian provinces this republican form of polity had never existed. There was a revolt—an attempt to re-establish the kingdom. This ended in the erection of Macedonia into a dependent province. The tone of the Romans towards the other Greek states now materially changed. Many citizens of Achaia who had taken part with the Macedonian king, at the close of the war were cited to Rome. A thousand were dispersed through different prisons in Italy; and of these, when set at liberty after a detention of seventeen years, only 300 survived. [The historian Polybius was of the number.] The Roman policy encouraged the mutual jealousies of the Grecian cities, and when at last they had recourse to arms—one after another—they fell an easy prey. Corinth, the wealthiest city in Greece, was plundered and sacked in the same year—some have said on the same day—as Carthage, in the year 590 of the city of Rome: and from that time the republican states of Central Greece ceased to be numbered among the nations.

It is not now necessary to trace further the transmarine conquests of Rome. To the close of this era her limits remained nearly of the extent which have been traced. We have now a new element added to the Roman state. There is, *first*, the city of Rome—by the citizens of which the magistrates are elected; within which is the seat of the central executive government, the central judicature, and the great council of the nation, the Senate. There is, in the *second* place, the rest of Italy, a multitude of municipalities regulating their own local affairs. The resources of this extensive country, both in men and money, are available to Rome in war; but the inhabitants have no control over that government—be they willing or unwilling, be it for their interest or not, they must move as it determines they shall move. *Lastly*, there are the foreign dependencies in Spain, North Africa, and Greece. These pay tribute into the national coffers, but they require standing armies to keep them in subjection. The Italian subjects of Rome are forced to furnish contingents to these permanent drains upon the best and most vigorous of their population. Tribute enriches the city of Rome alone. Before the reduction of Macedonia, the Roman citizens had been treated as subjects, and permitted themselves to be taxed. They were required at every census to make a return of their effects upon oath, and besides other stated or occasional contributions, paid a certain rate on the whole value of their property. But now they assumed the character of sovereigns; and having a treasury replenished with the spoils of other kingdoms, they entirely exempted themselves from their former burdens. In addition to the tribute of Macedonia came that of Carthage, the rents of Campania, and the tithes of Sicily and Sardinia. There was a marked increase in the magnitude and splendour of their public works. Owing to Rome's being the seat of election to all civil offices, it was inhabited almost exclusively by a few powerful and ambitious citizens, and by a mass of idle and venal ones. This led to the diversion of large sums of public money to private purposes, and a great increase of luxury. These two results combined to produce a third—the sharpening of the Roman appetite for war and plunder.

Having traced the workings of the Roman government externally, we now proceed to describe the development of the internal constitution of the government during this period. Elements of anarchy slumbered undeveloped in the Roman state at the close of the third era. There were the unsettled disputes of the patricians and plebeians; the inequality between the Roman citizens and the free citizens of the various Italian states, which had one after another been brought under the yoke of Rome.

The disadvantages under which the plebeians laboured led to those disputes in which the Gracchi successively took an active part. The agrarian law for which they contended was no foolish interference with honest industry and ambition. The practice of the Roman government was to appropriate certain portions of the territory of conquered states, and to settle colonies upon it. In these colonies, a fixed number of ploughgates were allotted to the plebeian, and a certain number to the patrician colonist. The patricians, however, had contrived to alter this first and tolerably equitable arrangement, and to make the new frame of government work on in the corrupt routine of the old. The plebeians had a consul of their own *caste*, but the government was as aristocratic as before. The public lands in the various states of conquered Italy, instead of being parcelled out as the law ordained, in certain proportions to colonists, were gifted in large blocks to the most wealthy patricians. Tiberius Gracchus, in his travels through Italy, saw that the effect of this illegal practice was to place large tracts of land in the hands of a few nobles who rarely visited them and who stocked their farms with slaves. The surplus population of Rome, for which these lands were intended to form an outlet, was meanwhile growing up in beggary and vice. The corruption at elections was teaching these lacklands to live upon alms. The emancipation of slaves by Roman citizens was bringing a yet lower admixture into close contact with the demoralized plebeians. Gracchus saw that this illegal allotment of the public lands was peopling Italy with slaves, debasing the plebeians, and converting the patricians into Oriental satraps. He sought to bring back their birthright to the poor and oppressed. This worthy Roman revolted from conquest and plunder, and resolved to struggle and to die in defence of the cause of the poor. He was vanquished. The degraded *caste* for whose rights he stood up slunk from his side. The patricians, when they could not otherwise get rid of him, did not hesitate to commit murder. His place was taken by his brother, who was in like manner murdered; and thus the powerful patricians were enabled to go on appropriating lands to which they had not the shadow of a right, and the electoral rabble of Rome were left to become more and more degraded. "Her jewels," as the noble-spirited mother of the Gracchi called her sons, were trampled under foot by those who knew not their value. But the assassination of the Gracchi by the Senate received its appropriate punishment. This was the first step in blood. Sylla and Marius revenged it tenfold. The extermination of so many families at Pharsalia can scarcely be regarded in any other light than as the necessary consequence and fitting punishment of the murder of the Gracchi.

The inequality between the Roman citizens and the other free Italians first attracted discussion about the year of the city 627. What better were the citizens of Rome than the other freemen of Italy? After some years of muttering and murmuring, Livius Drusus proposed, about the year of the city 660, that the Italian allies should be admitted to the rights of citizenship. The proposal was received with derision. The inhabitants of Italy, enraged at such a reception of their claim, began to form combinations. At Rome several persons favourable to their aims were sentenced to banishment. The news was immediately followed by a meeting of deputies from the majority of the Italian states at Corfinium to form a senate and elect consuls. Simultaneously twelve of the bravest and most powerful states—some of Etruscan, some of Oscan lineage—took arms, and sent envoys to Rome to demand the privileges of Roman citizens, the value of which had been so materially enhanced by their assistance. A supercilious reply from the Senate was followed by active hostilities on both sides. The Social War, as it has been called, lasted for four years, and ended with victory for the Romans. This victory, however, was purchased by conceding the right of citizenship to all the Italian states that did not rise in arms, or were induced to abandon the league before the close of the war. About the year of the city 670, all the free inhabitants of Italy from the Rubicon to the Straits of Messina were Roman citizens—Italy was Rome.

The full effects of this measure were not immediately perceptible. The number of citizens on the rolls was not

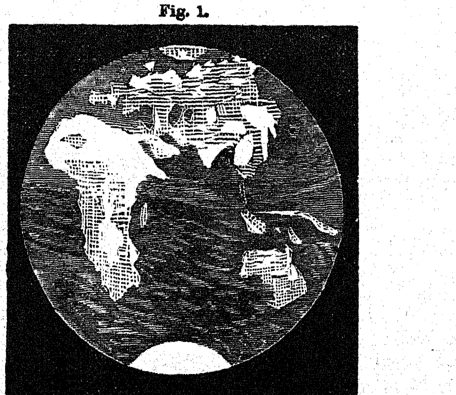
more than doubled; and as the elections could only take place at Rome, the name of citizen to all at a distance was an illusory title. The elections continued to be managed by the wealthy intriguers. The venal voters of the capital had received, however, a dangerous addition to their numbers. The slave of a Roman citizen became a Roman citizen by emancipation. Now, however, that the number of citizens was so much increased, the accession to the plebeian ranks from this source became so great that a law was introduced to check it. All the needy and serviceable clients of the patrician houses were made Roman citizens. The conduct of the senate towards the Gracchi had sanctioned the removal of political enemies by violent means; and this extension of the qualification of citizens introduced multitudes into the Comitia always ready to do such service. Rome became more corrupt than ever, and its permanent inhabitants continued, as before, the real masters of the state—because they were the electors of its rulers.

GEOGRAPHY.—CHAPTER IV.

ASTRONOMICAL RELATIONS OF THE GLOBE—GEOGRAPHICAL NOMENCLATURE—LAND AND WATER.

Modern astronomy exhibits the earth on which we live in a very different light from that in which it was viewed by its early inhabitants. Instead of the land being a vast plain, surrounded on every side by the sea, the sky stretching over it like a curtain, and the whole bounded by a bottomless abyss of impenetrable darkness, it has long since proved our earth to be a *globe* by many irresistible arguments, such as (1) the curved surface which the sea presents in every direction, for though we usually speak of "the level of the sea," we know it is really convex, because a high cliff is seen from the sea sooner than a low-lying shore, and topmasts are visible before the hulls of vessels make their appearance; (2) the circularity of the shadow it projects during eclipses of the moon; (3) the sun's rising earlier to those who dwell in the east than to those in the west, for were the earth a plane the sun's rays would illuminate its whole extent simultaneously; (4) the changes which take place in the objects seen in the sky as an observer's place is changed northwards or southwards, for, as one journeys north, the north pole of the heavens rises above the northern horizon and the south pole sinks out of view, and travelling south, the reverse occurs; (5) the actual measurements made by investigators, which show that the length of an arc of a degree of longitude gradually decreases as the latitude increases; but chiefly (6) the fact that its circumnavigation is now a feat of very ordinary occurrence.

Fig. 1.



Ideal View of the Earth from the Planet Mars.

Geography examines and explains the entire material organization of the globe (1) as a planet having its place among other bodies in space; (2) as a mass of matter, the outer crust of which exists in different conditions and configurations, is subject to mechanical and chemical changes, and contains and exhibits in itself memorials of events and modifications which have occurred during vast periods; (3) as the seat of organic life, animal and vegetable; and (4) as the special habitation of man as a living agent, influencing and influenced by the phenomena of nature.

The globe we inhabit is one of a small family of planets which revolve round the sun as their common centre, and are therefore called the *solar system*. This solar system itself is merely a unit in space, which, as far as the most powerful telescopes can penetrate, is filled with myriads of orbs and systems.

The earth revolves round the sun in an orbit of a somewhat *oval* shape, the sun being placed not exactly in the centre, but rather nearer the one end than the other, as fully explained under Astronomy. The earth is 24,000 miles in circumference, and its surface is calculated at 197,000,000 square miles; so that, compared to the size of the sun, it is in the proportion of a small pea to a globe 2 feet in diameter.

The earth is surrounded by an atmosphere which exerts a pressure of about 15 lbs. on every square inch of its surface, and which diminishes in density in a duplicate ratio as we ascend from the earth's surface, till, at the distance of 45 miles (or 40 miles above the tops of the highest mountains), it becomes so attenuated as to be almost imperceptible, and this distance, therefore, is set down as the highest limit to which its specific influence extends. From the sun the earth derives its light and heat, its summer and winter, its day and night; but were it not for the atmosphere which surrounds it, the advantages it receives from this luminary would be slight. Without an atmosphere there would be no reflection of light and heat; every object on which the sun's rays did not strike directly would be in total darkness, and the rays of heat being reflected by the earth back into space, an excessive cold would constantly prevail. The atmosphere, then, is the great recipient and distributer of light and heat, retaining the heat which is reflected back from the earth while intercepting and reflecting the direct rays of the sun. The cause of the increase of cold in proportion to every increase of altitude is the greater rarity of the atmosphere the higher we rise above the level of the sea. No other cause *can* be assigned for those eternal snows which cover the tops of the Himalayas under a vertical sun?

The figure of the earth is not a perfect sphere, but an *oblate spheroid*, being somewhat flattened at the poles, so that its longest diameter is rather above $7925\frac{1}{2}$ miles, and its shortest nearly 7899 miles, making a difference of about $26\frac{1}{2}$ miles, or a flattening of about $13\frac{1}{4}$ miles at each pole. It is considered that this result has been produced by the action of centrifugal force upon the globe before it was in a sufficiently hardened state. This flattening is the result of its spinning round so rapidly, and may be explained by what occurs when we are engaged in whirling a ball of soft matter, such as soft clay or putty, round an axis. It will be seen to assume this spheroidal shape. The mean density of the earth is five and a half times that of water—that is, this globe is equal in weight to one five and a half times its size composed of water—and the interior of the earth is double the density of the rocks, &c., composing the surface. From the temperature increasing in a certain ratio as we penetrate into the earth, it is believed that its interior is composed of an excessively hot mass, covered by an external hardened crust about 800 or 1000 miles thick. The annexed diagram (fig. 2) represents a small part of a section of the earth's crust; the dark line, A B, represents a thickness of 10 miles; the points, *m, m, m, m,* indicate the altitude of the highest mountains; the depth of the sea is shown by the openings, *s, s,* at the ends of the dark line; the dotted line, *a, a, a,* represents the height of the atmosphere—45 miles.

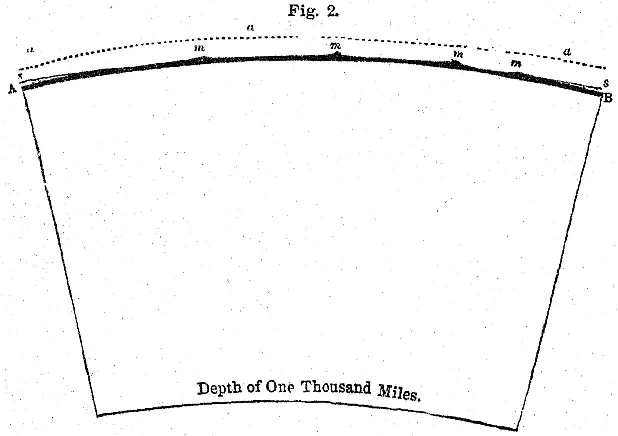
It requires but a glance at this sketch to show us how very minute is the portion of the earth's crust with which we are acquainted; three-fifths of the earth's surface are covered by seas, and another large portion by immense bodies of fresh water, by polar ice and eternal snows; so that, if we exclude the sandy deserts, morasses, &c., we scarcely leave one-fifth of it either accessible to the explorations or fit for the habitation of man and animals.

The earth we inhabit is a *round globe.* It revolves round its own axis every twenty-four hours (thus producing day and night), and accomplishes its journey round the sun in $365\frac{1}{4}$ days, to which circumstance we owe the alternations of the

seasons. It is also attended by a moon, revolving round it in $29\frac{1}{2}$ days. The moon is an opaque body, shining only by the reflected light of the sun; she is 240,000 miles distant from the earth, and only $\frac{1}{5}$ part of its size. To the attraction of the moon the tides of the ocean are mainly due, it being high water in every place when the moon is in the meridian.

All bodies are retained on the earth's surface by what is called the *attraction of gravitation;* that is, an inherent property with which it is found all particles and masses of matter are endowed, of drawing each other towards themselves. Were it not for this attraction, which causes all bodies on the earth's surface to tend to its centre, everything on the earth, and under the earth, nay, the very *earth itself*, would separate into millions of atoms of infinite minuteness, and be scattered in endless confusion through surrounding space.

Fig. 2.



Section of Solid Crust of the Globe.

As the earth is round, it is obvious that the people on the opposite side of the globe to us—*the antipodes*—must be standing with their feet to ours, and that the direction which is *up* to us, must be *down* to them—hence what we call *up* and *down* are merely relative terms; and that, as the surface of the earth is at the equator carried round at the rate of nearly 1000 miles per hour, the direction which we call *up* is never one instant the same.

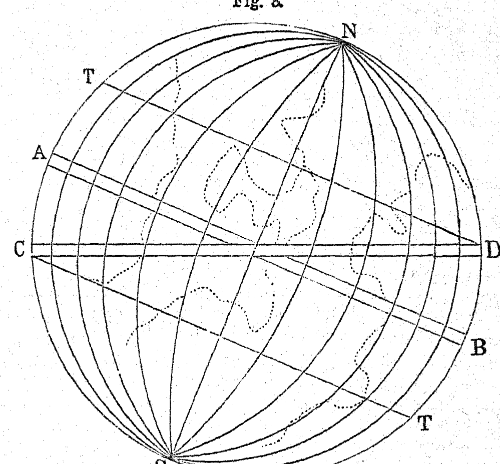
An individual shut up in a railway carriage, proceeding at the rate of 60 miles per hour, is quite unconscious of the velocity at which he is moving. It is not till he looks out at the window, and sees surrounding objects flying past in the opposite direction to that in which he is moving, that he becomes aware that he is being thus hurried along. The banks of a river appear in rapid motion westward to a person sailing in a steam-vessel down the stream in an eastward direction, while he fancies that the ship is at rest. In a similar way we are carried round the globe, by its diurnal motion from west to east, at a velocity of nearly 1000 miles per hour, or about 16 miles per minute, without consciousness on our part that we are in motion at all. In the latter case, the optical illusion is much more perfect than in the two former, yet it is exactly the same circumstance—the rapid motion of the earth from west to east—which gives rise to the apparent motion in surrounding bodies, and produces what seems to our eyes the diurnal revolution of all the heavenly bodies from east to west. This revolution of the earth round its own axis—which is accomplished every twenty-four hours—is called its *diurnal motion.*

Suppose—for the sake of clearer illustration of the earth's annual revolution round the sun—that a round ball, hanging on an axis, in a circular aperture, at the centre of a round level table, represents the sun; and that, suspended from a thread, another ball is carried slowly round the outer edge of the table, so that one half would be above and the other half below the surface of the table. This latter ball would represent the earth. The surface of the table would represent the *plane* of the earth's orbit; the point of suspension by the thread the *north pole*, the opposite point the *south pole*, and the line of section of the ball by the surface of the table would represent the line of the *ecliptic.* If, in addition to the motion round the table, the thread is slowly twirled round in the fingers, this would represent the *diurnal* or *daily revolution* of the earth; we would then have, so far, a tolerably correct idea of the motions of the earth. If, however, the earth revolved, as we have supposed, in any plane round the sun, having its axis at *right angles* or *perpendicular* to this plane, then we would have no alternation of the seasons, no variation in the length of the day and night; the winter in Britain would be hotter than the summer, from the earth's being in reality nearer the sun in its orbit at that period of the year than in our summer; and the sun would rise exactly at six a.m., and set at six p.m. from day to day, from week to week, and from year to year, for ever. The variation in the length of day and night in the temperate parts of the earth, and the change of seasons, are due to the earth's axis being inclined to the plane of its orbit, thus presenting alternately the northern and southern poles to the sun, as fully explained under ASTRONOMY.

The external crust of the earth, the surface of this oblate spheroid, with its phenomena of soil and climates, of organic products, and the changes wrought in it by man's past labours and present efforts, is the object of the geographer's investigation. The great abiding features of the surface of the earth—its continents and seas, its divisions and parts, its phenomena and productions, its historical changes under the operation of human action—come under his view. Every attempt to detail the nature and relations of the parts of the earth's surface requires a particular and preliminary knowledge of (1) position, (2) extent (*i.e.* horizontal configuration), and (3) form (*i.e.* vertical contour). *Position* is either positive or relative; *extent* involves real or approximate measurement, descriptive profile as well as composition and disposition of parts; *form* implies elevation and figure, and to all these geography gives attention.

To mark out the real positions and distances from any point, or from each other, of the different portions of land and water on the earth's surface, and to denote the relative locality where any particular spot is situated, as well as to indicate the probable climate and temperature which we may expect to find in any given place, every terrestrial globe and every map of the world, or of any portion of it, is covered over, one might say, with a number of artificial or imaginary lines.

Fig. 3.



A B, Equator. C D, Ecliptic. N S, Poles. T T, Tropics.

We have, first, the *equinoctial line*, or line of the equator, often also called, in familiar language, *the line.* It is an imaginary line encircling the middle of the globe at an equal distance from each pole, and dividing the surface of the earth into two equal portions, called the *northern* and *southern hemispheres.* It is called equinoctial because, when the apparent position of the sun is above that line, the day and night are of equal length.

The *equator* is divided into 360 degrees, and, by actual measurement, one of these degrees is found to contain 69½ English miles. By fixing upon any point on this encircling line to begin counting from, calling it 0, the distance of all places on this line, east and west, can be easily ascertained by knowing how many degrees they are from the starting point. All distances, eastward and westward, on the globe are measured by the length of a degree on the equator. These distances are called degrees of *longitude*, because they are the measurement of distance by the *length* of this line. If the distance extends eastward, it is called *east longitude;* if westward, *west longitude.* Since, then, the whole circle contains only 360 degrees, it is obvious that no place on the earth's surface can be further distant, east or west, than 180 degrees, *i.e.* the half of 360 degrees, from any other point.

By beginning at the starting point 0, and marking the different degrees of east and west longitude on the equator, and then by drawing lines from these to the poles, we have the *meridian lines*, or lines of longitude, into which the globe is artificially divided. The starting point 0, from which we begin to measure distances on the equator, is called the *first meridian*, and is quite arbitrary, it being a matter of no moment where we begin to measure, provided it be fixed and well known. Most nations begin counting longitude from the principal observatories of their respective countries. In Britain, and in several other countries, the observatory of Greenwich is adopted; in France, that of Paris, 2° 20′ 23″ E. of Greenwich; while in Germany, the island of Faroe, 18° 9′ 37″ W., is fixed as the first, or as it is sometimes called "the universal meridian."

The term *latitude* literally means *breadth*, and distance north or south from the equator is called latitude, because it is the measurement of breadth from that imaginary line. As every circle is divided into 360 degrees, if the first meridian, or that of Greenwich, be extended round the globe, intersecting the equator, as it must do, at right angles, it also must contain 360 degrees, the half of which, or the distance from the north to the south pole, must be 180 degrees; and one-fourth, or the distance from the equator to either of the poles, must be a quarter of a circle, or 90 degrees. The greatest possible difference of latitude is 180 degrees, *i.e.* 90° N. and 90° S. All places in the northern hemisphere, north of the equator, are in N. latitude; all places on the other hemisphere are in S. latitude. Hence, in the case of Greenwich 51° 28′ 38″ N., and Cape Town 34° 6′ S., the difference of latitude is the *sum* of their latitudes, viz. 85° 34′ 38″, because they are in opposite hemispheres.

When any place, then, is said to be so many degrees of north or south latitude, it is meant that it is so many times 69½ miles from the equator. These lines of latitude are parallel to the equator; hence they are called *parallels of latitude.* The lines of latitude being parallel, a degree of it can be measured exactly on any portion of the globe. But since the meridian lines of longitude all meet at the poles, the distance between them must be less the further away they are from the equator; the standard measure of a degree of longitude must refer therefore to the length of a degree on the equator, as otherwise these degrees would become shorter and shorter the further from the equator and the nearer the poles, so that we would have a different measurement of a degree of longitude for every change of a degree of latitude. As the earth is a spheroid, the length of a degree of longitude varies in different latitudes, and may be found on calculation to yield the following as their measurements in English miles:—*

Lat.	Lat.	Lat.	Lat.
0° = 69·07	25° = 62·53	50° = 44·35	75° = 17·86
5° = 68·81	30° = 59·75	55° = 39·58	80° = 11·98
10° = 67·95	35° = 56·51	60° = 34·50	85° = 6·09
15° = 66·65	40° = 52·85	65° = 29·15	90° = 0·00
20° = 64·84	45° = 48·78	70° = 23·60	

On two days only, during the year, does the apparent daily course of the sun coincide exactly with the equinoctial line. This happens at what are called the vernal and autumnal equinoxes, when day and night are equal. During the intervening periods the sun appears to travel so many degrees north and so many degrees south, producing (1) the changes of the seasons, and (2) the variation in the length of day and night, the cause of which, as above stated, is the earth's axis being *inclined to the plane* of its orbit.

If we could see the stars during the day, so as to enable us to mark the sun's course among them, it would be found that he is constantly shifting his relative position; that a star which appears a little eastward of the sun to-day would, in a few days more, pass the sun and be seen to the westward of that orb, and that thus the sun appears to be pursuing a *backward* course among the stars, completing a whole round of the heavens backwards in a year. This annual path of the sun is denominated the *line of the ecliptic*, because it is when the moon crosses this line in her orbit that eclipses happen. The line of the ecliptic is in reality the *plane* of the earth's orbit.

If the apparent daily course of the sun, referred to in the preceding paragraph, were marked out in the heavens by a golden belt, on the day of the vernal or autumnal equinox, this belt would represent the *equinoctial line.* If a mark were put in the sun's place in the heavens every day at noon for a whole year, this dotted line would make a complete circle of the heavens, shifting its relative position daily; it would intersect the equator at two opposite points, would reach 23½ degrees north of that line on one side of the circle, and the same distance south on the opposite side, and this dotted line would represent the *ecliptic.*

Again, if the apparent path which the sun describes during the longest day were traced on the heavens, when he is at the extreme northern point in the ecliptic, the path thus marked out would indicate the artificial line called the *tropic of Cancer;* and if the sun's apparent course were traced on the heavens during the shortest day, or when he has arrived at his extreme point in the ecliptic southward, this course would indicate the *tropic of Capricorn;* vertically under these lines similar lines may be traced on the earth. The former of these is 23½ degrees *north*, the latter 23½ degrees *south* of the equator, and all the countries situated between these lines are said to be *within the tropics.* These lines are called the *tropics* because the sun in his apparent course in the heavens never crosses them, but appears, when he arrives at them, to *turn* back. The sun is always in the zenith at some point between these tropics.

The Zones.—The broad equatorial belt, within which the sun's rays are vertical twice a year, included between these two lines, inclosing a space of 47 degrees (*i.e.* 23½ + 23½), is called the *Torrid Zone*, from the great heat which almost always prevails there. The days and nights are of nearly equal length through the whole year; the sun rises nearly due east, mounts upwards right overhead, and sets nearly due west; his rays therefore fall almost perpendicularly at mid-day (which is the cause of the intense heat), and at that hour the inhabitants have no shadow. The only change of seasons which is there experienced are the wet and the dry seasons: during the former the earth is deluged with great torrents of rain; during the latter it is scorched and burned up by the piercing rays of a vertical sun. In this portion of the earth the dreaded hurricane, the fearful tornado, and the devastating earthquake exert their greatest fury, and produce the direst effects. There, too, do the animal and vegetable kingdoms exist in greatest size and luxuriance; the most plenteous herbage, the most enormous trees, the most delicious fruits, animals of the largest size, birds of the gayest plumage, and reptiles of the most venomous species, are all found in this "clime of the sun." But there, too, man exhibits his animal propensities in the most exaggerated form, while his spiritual and moral nature seems in a proportionate degree deteriorated.

Parallel to, or concentric with, the tropics and the equator, at the distance of about 23½ degrees from each pole, we have other two artificial or imaginary circles which surround the globe; the one on the northern hemisphere is called the *Arctic* or *Northern Circle;* the one on the southern, the *Antarctic Circle.* The portions of the earth included between these two circles and the poles are called the *North* and *South*

* An English mile is nearly six-sevenths of a nautical one. Of the former there are 69¼ in a degree; of the latter, 60.

Frigid Zone respectively. In the north frigid zone, the only appearances of vegetation are a few stunted shrubs and mosses; the inhabitants are few in number, thinly scattered, and of very diminutive stature. The south frigid zone is entirely destitute of traces of man; and plants and animals, if any exist, must be extremely few. Both the north and south frigid zones are in darkness for a part of the year, for another part there is constant twilight, and for a third part the sun never sets. Around both poles the regions consist entirely of frozen wastes and impassable barriers of ice. At each pole the year consists of a single day and night, each of six months' duration, the sun appearing to move only in the line of the ecliptic, and the stars to retain a fixed position.

Those portions of the globe included between the Arctic and Antarctic circles and the tropics are denominated, respectively, the *North* and *South Temperate Zones.* They each occupy a breadth of 43 degrees, and both together occupy nearly two-thirds of the earth's surface. The greater portion of the land is found in the north temperate zone. The sun's heat, in these zones, diminishes in power the higher the latitude. Although the north and south portions of these zones partake more or less of the nature of the adjoining torrid or frigid zones, still the greater part of these extensive regions enjoy a mild and genial climate; they are blessed with the pleasing vicissitude of spring, summer, autumn, and winter, succeeding each other at different periods of the year. They produce those crops and other necessaries best suited for man in his most perfect condition on earth. Man is here more distinguished for intellect, intelligence, and industry than on any other portion of the earth's surface.

The people who live north of the tropic of Cancer have the sun always due south at mid-day; those who live south of the tropic of Capricorn have the sun due north at mid-day; while those who live within the tropics have the sun at noon due north during one period of the year, and due south during another period; and twice every year they have the sun at mid-day in their *zenith*, or in that point in the heavens directly over their heads.

Of these zones the torrid zone is the largest, being about ten times the size of either of the frigid zones, and nearly one-third larger than either of the temperate zones. (See fig. 3.)

As a *Map* is a representation of the whole earth (or of a part of it) on a flat surface, since it is impossible correctly to represent a globe on a flat surface, it follows that all maps are more or less inaccurate. When the portion of the surface of the globe represented is small, the inaccuracy is trifling. Maps are indispensable aids to the senses in enabling us to acquire a knowledge of the form, size, appearance, &c., of the various divisions of the surface of the earth.

The upper part, or top of a map, represents the *North;* the lower part, the *South;* the right side, the *East;* the left side, the *West.* A place is said to be *north* of one *below* it, *south* of one *above* it, *east* of one to the *left*, and *west* of one to the *right.* All maps show the parallels of latitude running from side to side, and the meridians or lines of longitude from top to bottom.

The great *natural* divisions of the earth's surface are those of Land and Water.

Under the designation *Land*, geographers include every variety of rock-formation or of mineral substance existing in a solid form and not constantly covered by water. Under the term *Water* they comprehend all the terrestrial, as distinguished from the atmospheric accumulations of that peculiar fluid by which land is surrounded. While this definition of water is meant to exclude rain and dew, it includes their accumulations in springs, wells, pools, lakes, streamlets, rivers, and seas.

Many technical terms are—for the sake of accuracy of description and brevity, as well as clearness of explanation—employed in geography as in other scientific studies. These require to be correctly understood and carefully remembered. They ought also to be distinctly and tersely defined, in plain and easily understood language. The following are a few of these terms and their definitions:—

Land.	*Water.*
Continent.	Ocean.
Country.	Sea.
Island.	River.
Peninsula.	Lake.
Isthmus.	Gulf.
Promontory.	Bay.
Cape.	Creek.
Coast, or	Strait.
Shore.	Channel.

A *Continent* is a great extent of land connected and continuous, *i.e.* not disjoined or interrupted by a sea.

An *Island* is a tract of land wholly disjoined by water from those larger masses called continents.

Islands are of two sorts—*continental*, *i.e.* near to or connected with a continent; or *pelagic*, *i.e.* lying in the open sea. Islands in irregular juxtaposition constitute *groups;* in regular juxtaposition, *chains.*

A *Peninsula* is a portion of land connected by a narrow neck with a larger mass of land than itself, and nearly surrounded with water.

An *Isthmus* is a narrow neck of land by which two continents are connected, or by which a peninsula is united to the mainland.

A *Cape*, *Promontory*, *Point*, *Headland*, *Head*, *Mull*, *Foreland*, *Naze* or *Ness*, is a portion of land jutting out into the sea beyond the common shore.

A *Point* is the extremity of a promontory when low; a *Tongue* is lower than a point, a *Spit* higher.

A *Plateau* or *Table-land* is a tract of level land elevated above the surrounding country.

A *Plain*, *Prairie*, *Savannah*, *Steppe*, or *Pampa*, is an extensive tract of land, mostly level, and destitute of trees.

An *Ocean* is a large uninterrupted extent of sea.

A *Sea* is a portion of salt water of less extent than an ocean.

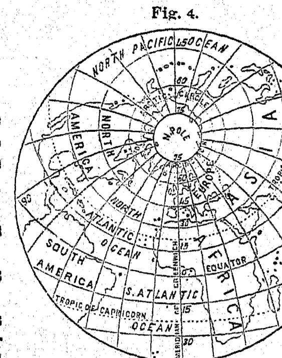
A *Strait* is a narrow neck of water joining two seas, or connecting a sea or gulf with the ocean.

A *Sound* is a strait so shallow that it may be fathomed.

A *Channel* is a wider and larger passage between two seas, than a strait.

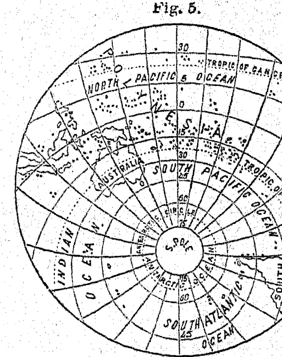
A *Gulf* is a portion of water almost surrounded by land, or a recess of the sea or ocean from the general line of the shore into the land.

Fig. 4.



Land Hemisphere.

Fig. 5.



Water Hemisphere.

A *Bay* is a bend of the sea into the land, with a wider neck or opening than a gulf.

A *Frith* or *Estuary* is a narrow strip of sea stretching inland, receiving the waters of some river.

An *Archipelago* is a cluster of islands.

A *Road* or *Roadstead* is anchorage ground for ships near a harbour.

A *Cove* is a small gulf; a *Creek*, a small arm of the sea.

A *Lake* is an extensive collection of water contained in a cavity or hollow of the land.

The *political* divisions of the earth are principally Empires, Kingdoms, and Republics.

An *Empire* comprehends several countries or states, united under one ruler, who is generally styled an *Emperor*.

A *Kingdom* is a state or country governed by a *King*.

A *Republic* is a country whose rulers are chosen by the people.

A superficial glance at any map of the world will show that there is much more land on the north than on the south side of the equator; that the great bulk of the different continents lies on the northern half of the globe, while the southern half is mainly covered by water, as shown in figs. 4, 5. London is in the centre of one hemisphere, and a point a little to the south-east of New Zealand is taken as the centre of the other. Concentric circles are drawn at a distance of 1000 miles apart, round these centres. London is therein shown to be in the centre of the whole land portion of the globe, while the other hemisphere—except for the lower extremity of South America and of Australia and its neighbour islands—consists of ocean surface.

The extent of land on the north side of the equator, compared to that on the south side, is nearly in the proportion of 3 to 1.

	Square Miles.
Land on *north* side of the Equator, . . .	38,000,000
Land on *south* side of the Equator, . . .	13,500,000
Water on *north* side of the Equator, . .	60,500,000
Water on *south* side of the Equator, . .	85,000,000

The representation of the whole surface of the globe cannot be correctly exhibited at one view on a map. To accomplish this object, two halves or hemispheres—generally the *Eastern* and *Western* Hemispheres—are employed.

The eastern hemisphere comprehends the largest continental mass of land on the earth's surface. As it is that part, also, which has been known to mankind from the most remote antiquity, it is hence called the *Old World*. The continent of land on the western hemisphere is often called the *New World*, from its having been unknown to the inhabitants of the Old till the voyage of the celebrated Columbus, at the close of the fifteenth century.

Land.	Square Miles.
In Eastern Hemisphere or Old World, . .	37,000,000
In Western Hemisphere or New World, .	14,500,000

There are thus about *two and a half* times as much land on the eastern as on the western hemisphere.

Divisions of Land on the Earth's Surface.—Till of late years, geographers almost invariably divided the dry land on the globe into four quarters—viz. Europe, Asia, Africa, and America; now, however, the following divisions are common:

(1.) Europe, Asia, Africa, North America, South America, Australasia.

(2.) Europe, Asia, Africa, North America, South America, Australasia, Polynesia.

(3.) Europe; Asia; Africa; America—North and South; Oceania—Malaysia, Australasia, Polynesia.

A glance at a map of the great eastern continent or hemisphere, at once shows that it ought to be naturally divided into two continents, one portion of it—Africa—being joined to the rest by a very narrow neck of land, called the Isthmus of Suez, about 70 miles wide; it is separated from the other portion by the Mediterranean and Red Seas. The other part of the great mass of land on this hemisphere, however, is again divided into two continents, Europe and Asia; the division between these is more artificial, being the Black Sea, the Caspian Sea, the Sea of Marmora, a river, and two ranges of mountains.

The continents of Europe and Asia extend from east to west, their greatest length being parallel to the equator. The continents of Africa, North and South America, stretch from north to south.

The western hemisphere is naturally divided into two continents—North and South America. These are connected by the narrow Isthmus of Panama, which is at one part only 28 miles from sea to sea.

Oceania, also called the Maritime World, is partly situated in both hemispheres. It comprehends Australia and the numerous groups of islands in the Pacific Ocean.

Divisions of Water on the Earth's Surface.—As, in strict language, there are only *two* great continents of land, so, properly speaking, there is only *one* great ocean, which covers seven-tenths of the globe. For the sake of convenience, however, this great body of salt water has been regarded as divided into *five* oceans, which have received different names, and are, in some degree, separated from one another by the large continental masses of land. These are—the Atlantic Ocean, the Pacific Ocean, the Indian Ocean, the Northern or Arctic Ocean, and the Southern or Antarctic Ocean.

The Atlantic Ocean is bounded by the continents of Europe and Africa on the east, and the continents of North and South America on the west.

The Pacific Ocean covers more than half the globe, and is bounded on the east by the continents of North and South America, and on the west by the eastern shores of Asia, Australia, &c.

The Indian Ocean lies between the shores of India on the north, and the great Southern or Antarctic Ocean on the south; the continent of Africa bounds it on the west, and the compact land-mass of Australia on the east.

The Northern or Arctic Ocean lies north of the great continents and of the Arctic circle, and surrounds the North Pole.

The Southern or Antarctic Ocean surrounds the South Pole, and lies south of the Antarctic circle.

Here is a rough estimate of their extent and areas:—

Name.	Greatest Breadth.	Area in Square Miles.
Atlantic Ocean, ...	5,000 miles.	25,000,000
Pacific Ocean, ...	12,000 "	50,000,000
Indian Ocean, ...	4,500 "	20,000,000
Arctic Ocean, ...	2,000 "	15,500,000
Antarctic Ocean, . . .	...	35,000,000

The following general facts appear to emerge from the investigations which have been made regarding the relative proportions and positions of land and water. Out of 197,000,000 British statute square miles 145,000,000 are covered by the waters of the sea. Of the space lying between the equator and the Antarctic circle—that is, the southern half of the torrid zone and the south temperate zone—the surface of which extends to 90,000,000 square miles, nearly seven-eighths, or 77,000,000 square miles, are covered by water; while in the corresponding space in the northern hemispheres the land is, comparatively speaking, almost equal to the water. This great irregularity in the distribution of land has never been accounted for in a way quite satisfactory to the reason. There can be no doubt that there are good reasons which may yet be discovered, why the closely-compacted masses of the continents of the Old World should be so differently constituted—in its great stretch from east to west round nearly one-half of the circumference of the globe—from those of the New World in its long and comparatively narrow extension from the icy oceans of the Arctic north to the cold regions of the Antarctic south, a continuous mass of land exceeding 9000 miles in length. No less wisely has it been arranged, we must believe, that a hemisphere having its polar centre in the south of England should be able to include within its boundary line the greater part of the land on the globe's surface, and that around a south pole at the opposite end of that axis, near New Zealand, there should be presented to the eye a wide-spreading hemisphere mainly of sea. If there be causes for the striking facts regarding the relative positions and extents of ocean-breadths and continental-masses, they may surely be found. May it not be that the external form and the differing positions of the land had for their prevailing cause the possibility of ready access from land to land, the realizing in man a brotherhood of commerce, community, and contentment, and that the ocean highway might unite the whole race in aim, interest, and sympathy?

THE FRENCH LANGUAGE.—CHAPTER V.

THE GENDER OF NOUNS—ADJECTIVES: THEIR NUMBER, GENDER, COMPARISON, AND GENERAL USE.

As adjectives agree with the substantives they qualify in gender, number, and case, we cannot proceed to the consideration of the adjective until we have in some measure noted and disposed of the most knotty of all the difficulties which the student of French encounters in his endeavour to acquire the mastery of that language—the gender of nouns. The attainment of a practical, conversational, everyday use of the most perspicuous of continental tongues is made very embarrassing to a learner by this one subject. Many people who have gained an otherwise fair proficiency in the language, begin to be hesitant when they speak in it, lest they should blunder on this head. Many ingenious endeavours have, it is true, been made to give trustworthy guidance in regard to the genders of French nouns, and no small amount of industry has been spent in the attempt to find easy methods of overcoming this crucial intricacy. Several treatises of considerable size have been devoted to its explanation; elaborate systems of rules, full of cross-references to exceptions, sub-exceptions, and counteracting rules have been put forth, often accompanied by tables of a nature so complicated that the skill of a mathematician could scarcely unravel their mysteries; trite tractates also, professing to elucidate the whole matter, in an explicit way, in a few hours' time, have been pressed upon public attention, and yet no really workable system of general principles or rules has been found.

French grammarians themselves often refer to the arbitrary manner in which gender has been allocated to French nouns. Of course the French language is a language adapted to the nature of the French mind, and to them the most delicate niceties of their living mother-tongue are matters of the merest familiarity; but of this intricate and important difficulty in the mastery of the language no successful solution has been furnished. It is one of the peculiarities of gender in French, for instance, that the fair sex—*le beau sexe*—is masculine, while the historic heroes of that warlike race, the French Guards—*les gardes françaises*—are feminine. On the whole, therefore, so far as regards the acquirement of a practical knowledge of French gender, we know of no easier or better plan than careful reading, combined with watchful observation—taking for our safest and simplest guide the common-sense rule of M. Emile de Bonnechose, "Every noun before which the usage of the best authors permits *un* or *le* to be put is *masculine*, and those before which *une* or *la* may be placed are *feminine*."

There are only two genders recognized in French—*masculine* and *feminine;* the former of these being the chief indefinite generic gender, and the latter the extraordinary distinguishing and specific one. There are no *neuter*, though there are some *common*, nouns.

The gender of French nouns is mainly determined either (1) by their meaning; (2) by their form; (3) by analogy or similarity of suggestiveness; or (4) by derivation and similarity of termination.

I. We may generally expect to find the following classes of nouns to be masculine:—

Nouns denoting the higher intelligences or supernatural beings; as *le Dieu*, God; *le cherub*, the cherub; *l'ange*, the angel; *le diable*, the devil; *le vampire*, the vampire.

Nouns denoting males or occupations usually followed by males; as *le baron*, the baron; *le père*, the father; *le berger*, the shepherd; *le boucher*, the butcher. Among the exceptions to this rule are—

La bête,	*the beast or fool.*	La pratique,	*the customer.*
La dupe,	*the dupe.*	La personne,	*the person.*
La connaissance,	*the acquaintance.*	Sa sainteté,	*his holiness.*
Sa majesté,	*his majesty.*	La sentinelle,	*the sentinel.*

The names of the days of the week, months, and seasons, except *la Dimanche*, Sunday, *la semaine*, the week, *la saison*, the season, and sometimes *automne:*—

Le Lundi,	*Monday.*	Le Jeudi,	*Thursday.*
Le Mardi,	*Tuesday.*	Le Vendredi,	*Friday.*
Le Mercredi,	*Wednesday.*	Le Samedi,	*Saturday.*

La Dimanche, *Sunday.*

Le Janvier,	*January.*	Le Juillet,	*July.*
Le Février,	*February.*	L'Août,	*August.*
Le Mars,	*March.*	Le Septembre,	*September.*
L'Avril,	*April.*	L'Octobre,	*October.*
Le Mai,	*May.*	Le Novembre,	*November.*
Le Juin,	*June.*	Le Décembre,	*December.*
Le printemps,	*the spring.*	L'automne,	*the autumn.*
L'été,	*the summer.*	L'hiver,	*the winter.*

Most names of metals and minerals; as *le fer*, iron; *le cuivre*, copper; *le granit*, granite; *le charbon*, coal. Among other exceptions *la pierre*, stone.

Most names of colours; as *le rouge*, red; *le gris*, grey: except *la rose*, pink; *la pourpre*, purple.

Proper geographical names; as *le Portugal*, *le Danemark;* except those ending in *e* or *es*, which are feminine; as *la France.*

Words used in the decimal notation; as *le litre*, *le franc*, *le mètre.*

Words ending in *b, c, d, g, h, k, l, p, q, y.*

Most words ending in *a, j, o, u, f, m, n, r, s, t.*

II. The following classes of nouns are usually feminine:—

Names of females, and female dignities and occupations; as *la sœur*, the sister; *la reine*, the queen; *la nourrice*, the nurse.

Abstract nouns: these include a very large part of the French vocabulary, and they generally end in *euse, esse, eur, erie, ise, ion, té, ude, ure, ade;* as *la sagesse*, wisdom; *la peur*, fear; *la satisfaction*, satisfaction; *la fortitude*, bravery, &c.

The student will soon notice that French feminine nouns tend to end in a long and almost drawling syllable, like the terminations of the abstract nouns given above, and many feminines end in a double consonant, followed by *e* mute. Masculine nouns, on the other hand, tend to end in a short and almost abrupt sound; as *le franc*, *le plan*, *le coquin* (rogue).

A number of French nouns have two genders, and a different meaning for each; as—

Un livre,	*a book.*	Une livre,	*a pound.*
Un manche,	*a handle.*	Une manche,	*a sleeve.*
Un mémoire,	*a bill.*	La mémoire,	*the memory.*
Un office,	*an employment.*	Une office,	*a buttery.*
Un page,	*a page-boy.*	Une page,	*the page of a book.*
Le Pâque,	*Easter-day.*	La Pâque,	*the Passover.*
Un pendule,	*a pendulum.*	Une pendule,	*a clock.*
Un période,	*a period of time.*	Une période,	*a full stop.*
Un poële,	*a stove.*	Une poële,	*a frying-pan.*
Un poste,	*an employment.*	Une poste,	*a post-office.*
Un satire,	*a satyr.*	Une satire,	*a satire.*
Un somme,	*a short sleep.*	Une somme,	*a sum of money.*
Un souris,	*a smile.*	Une souris,	*a mouse.*
Un tour,	*a trick, a turn.*	Une tour,	*a tower.*
Un triomphe,	*a triumph.*	Une triomphe,	*a trump.*
Un vase,	*a utensil.*	La vase,	*slime.*
Un voile,	*a veil.*	Une voile,	*a sail.*

ADJECTIVES.

Having acquired, as far as possible, a knowledge of the nature and effect of the gender of nouns in the common use of language, we are able to proceed to consider the other part of speech which is influenced by considerations of gender. We therefore have now to explain the nature and property of the adjective.

Adjective (Lat. *ad*, to, and *jectus*, joined) is the name given to that kind of words which adds to the precision of speech, by bringing full into the view of the mind the qualities of the object of which we may be speaking. Adjectives are chiefly used to distinguish and particularize what we are ourselves thinking (or wanting others to think) about, by mentioning some characteristic which separates it from other things, and so limits and determines the class of things to which the attention is directed. For example, "*a* horse" means any horse; "a *good* horse" qualifies the noun and limits the class spoken of, by excluding all bad ones; "a *good gray* horse" qualifies it still more; while "*my good gray* horse" almost particularizes it.

Adjectives are of two kinds—(1) Qualificative, *i.e.* expressing some quality or peculiarity of the noun, as *mauvais*

temps, bad weather. (2) Determinative, *i.e.* determining or defining the meaning, as *mon chapeau*, my hat.

I. Qualificative Adjectives.

Most adjectives and participles, especially those ending in *d, é, i, r, s, t,* and *u*, are made feminine by the addition of *e* mute; as *grand*, great, *grande; donné*, given, *donnée; vrai*, true, *vraie; gris*, gray, *grise; couvert*, covered, *couverte; vu*, seen, *vue.* This rule includes the great majority of French adjectives. The following are exceptions:—

Mas.		*Fem.*	*Mas.*		*Fem.*
Coi,	*shy,*	coite.	Frais,	*fresh,*	fraîche.
Favori,	*favourite,*	favorite.	Absous,	*absolved,*	absoute.
Bas,	*low,*	basse.	Beau,	*handsome,*	belle.
Épais,	*thick,*	épaisse.	Fou,	*mad,*	folle.
Gras,	*fat,*	grasse.	Mou,	*soft,*	molle.
Gros,	*large,*	grosse.	Nouveau,	*new,*	nouvelle.
Las,	*tired,*	lasse.	Mat,	*dull,*	matte.

Before a masculine word beginning with a vowel or *h* mute *beau, fou, mou,* and *nouveau* become *bel, fol, mol,* and *nouvel.*

Masculine words, whether used as nouns or adjectives, ending in *eur* sometimes change *eur* into *euse;* as *trompeur*, deceitful, *trompeuse;* and when they end in *teur* frequently make in the feminine *trice;* as *consolateur*, consoling, *consolatrice.*

Adjectives ending in *e* mute do not change; as *facile*, easy; feminine *facile.*

Those ending in *et, ot, el, eil, on, en* double the last consonant and add *e* mute; as *muet*, dumb, *muette; sot*, stupid, *sotte; bel*, handsome, *belle*, &c.; but note *malin*, malicious, *maligne; bénin*, benign, *bénigne.*

Some adjectives ending in *et* change *et* into *ète* for the feminine:—

Mas.		*Fem.*	*Mas.*		*Fem.*
Complet,	*complete,*	complète.	Secret,	*secret,*	secrète.
Discret,	*discreet,*	discrète.	Inquiet,	*inquiet,*	inquiète.

Those ending in *c* change *c* into *que*; as *public*, public, *publique;* or into *che;* as *blanc*, white, *blanche; sec*, dry, *sèche; franc*, frank, *franche; Franc*, French, makes *Franque.*

Those ending in *f* change *f* into *ve;* as *actif*, active, *active.*

Those ending in *g* add *ue;* as *long*, long, *longue.*

Those ending in *x* usually change *x* into *se;* as *heureux*, happy, *heureuse*; but *doux*, sweet, becomes *douce; roux*, red, *rousse; faux*, false, *fausse.*

According to its meaning, the same word may be (1) an adjective, indicating a state or quality; or (2) a participle, expressing an action in the course of performance. The former are variable, the latter invariable, as the following illustrative examples will show:—

ADJECTIVES.

Les âmes aimantes sont propres à l'étude de la nature.	*Loving spirits are fit for the study of nature.*
L'artiste a fait deux portraits parlants.	*The artist has made two speaking likenesses.*

PARTICIPLES.

Les âmes aimant Dieu se reposent en lui.	*Souls loving God repose themselves on him.*
Qu'on ne vous trouve point tous deux parlant ensemble.	*Don't let us have two speaking at once.*

In order that this distinction may be more clearly brought out, in many cases the present participle undergoes a change when it becomes an adjective; such are—

ADJECTIVES.	PARTICIPLES.	ADJECTIVES.	PARTICIPLES.
Équivalent.	équivalant.	Intrigant.	intriguant.
Expédient.	expédiant.	Précédent.	précédant.
Fabricant.	fabriquant.	Violent.	violant.

The following examples will show how adjectives are used. The student should notice (1) what gender they denote; (2) in what way the feminine is formed. It will be advisable to read the sentences aloud, and more advantageous still would it be if they were almost committed to memory, so that on looking at the sentence in the one language the student could at once give the corresponding sentence in the other, covering with a card, or otherwise, the one column while translating the other:—

Le pouvoir temporel,	*the temporal power.*
La puissance temporelle,	*the temporal power.*
Un ancien usage,	*an ancient custom,*
Une ancienne loi,	*an old law.*
Un frère cadet,	*a younger brother.*
Une sœur cadette,	*a younger sister.*
Un pied mignon,	*a little foot.*
Une bouche mignonne,	*a small mouth.*
Un sort heureux,	*a happy fate.*
Une condition heureuse,	*a pleasant state.*
Un lion furieux,	*a furious lion.*
Une lionne furieuse,	*a furious lioness.*
Un spectacle curieux,	*a strange sight.*
Une foule curieuse,	*an inquisitive crowd.*
Un testament nul,	*a void will.*
Une clause nulle,	*an obsolete clause.*
Un brouillard épais,	*a thick mist.*
Une herbe épaisse,	*a thick grass.*
Un gros livre,	*a large book.*
Une grosse somme,	*a great sum.*
Un petit garçon gentil,	*a gentle little boy.*
Une petite fille gentille,	*a gentle little girl.*
Un son aigu,	*a sharp sound.*
Une voix aiguë,	*a shrill voice.*
Un jardin contigu,	*a neighbouring garden.*
Une maison contiguë,	*a semi-attached house.*
Un caractère altier,	*a haughty character.*
Une démarche altière,	*a proud gait.*
Un chapeau neuf,	*a new hat.*
Une robe neuve,	*a new dress.*
Un esprit vif,	*a quick wit.*
Une imagination vive,	*a lively imagination.*
Un ton bref,	*a brusque tone.*
Une parole brève,	*a short speech.*
Un ange consolateur,	*a consoling angel.*
Une parole consolatrice,	*a comforting word.*
Un signe accusateur,	*an accusing sign.*
Une voix accusatrice,	*an accusing voice.*
Un idiome étranger,	*a foreign idiom.*
Une langue étrangère,	*a strange tongue.*
Un succès passager,	*a passing success.*
Une beauté passagère,	*a passing beauty.*
Le père indulgent,	*the indulgent father.*
La mère indulgente,	*the indulgent mother.*
Aux pères indulgents,	*to the indulgent fathers.*
Aux mères indulgentes,	*to the indulgent mothers.*

When in English *with, of, from,* and *by* follow adjectives and participles, these prepositions are generally expressed in French by *de*, which is repeated before each noun.

The English *by* after a comparative, *in* after a superlative, and *than* before a number are also expressed by *de.*

In general, all adjectives which signify plenty, scarcity, want, are followed by *de;* such are—

Absent.	Contrit.	Envieux.	Las.
Amoureux.	Coupable.	Fier.	Libre.
Avide.	Digne.	Honteux.	Mécontent.
Capable.	Doué.	Incapable.	Plein.
Content.	Ennuyé.	Jaloux.	Sûr.

De is also used after all adjectives which follow the *impersonal* verb *être;* as *C'est horrible de trouver que* . . . , It is horrible to find that . . .

Adjectives expressing aptness, fitness, tendency, or any habit are followed by *à;* such are—

Accessible.	Contraire.	Nuisible.	Semblable.
Adonné.	Favorable.	Pareil.	Sensible.
Antérieur.	Inaccessible.	Prêt.	Sujet.
Attentif.	Insensible.	Propre.	Utile.

FORMATION OF THE PLURAL OF ADJECTIVES.

Adjectives form their plural by adding *s* both in the masculine and feminine; as *grand, grands; grande, grandes,* great.

This rule is without exception for the feminine, but the masculine has the following exceptions:—

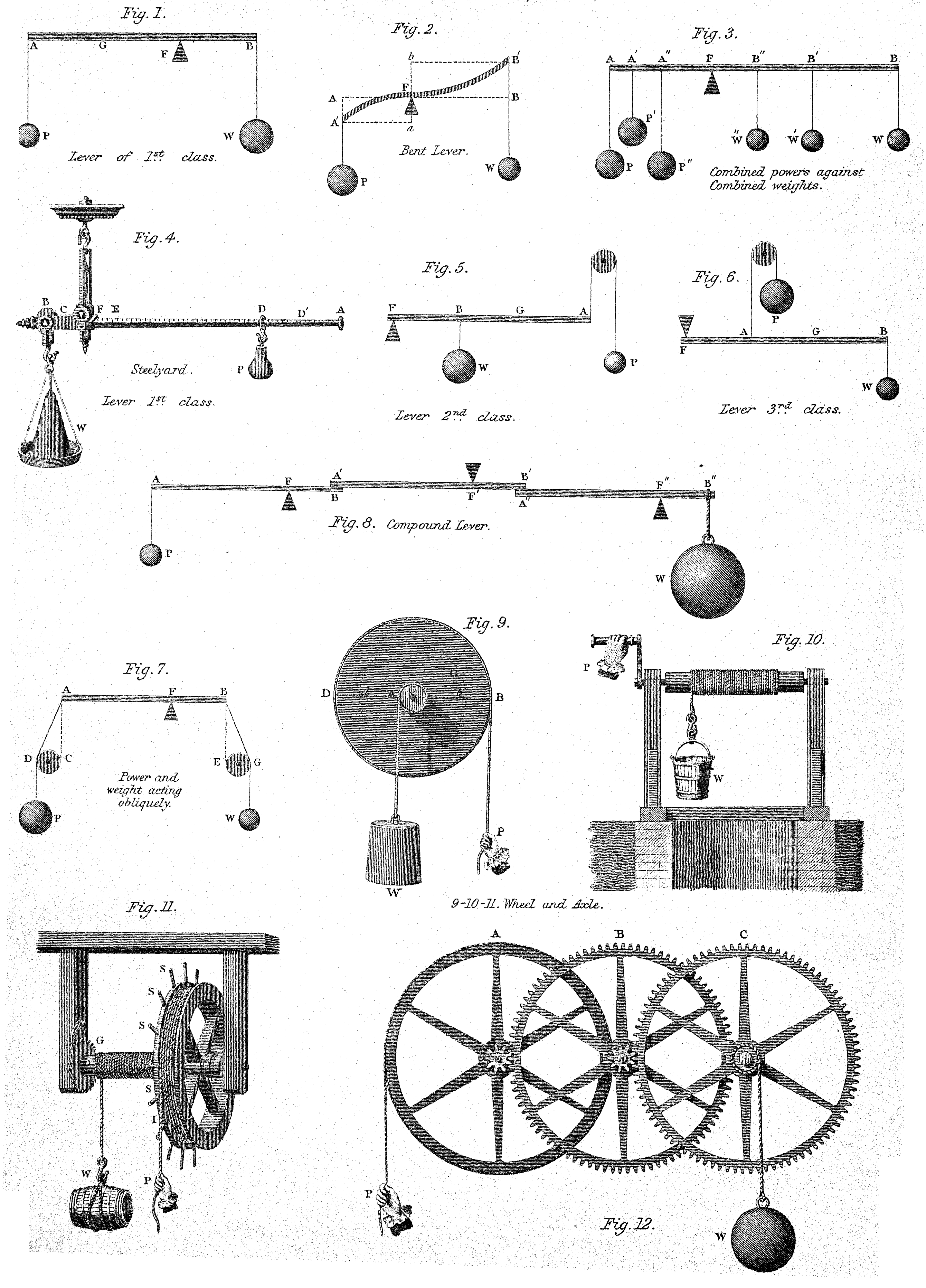
Adjectives ending in *s* or *x* do not change their termination in the plural; as *malheureux*, unhappy, *épais*, thick, &c.

Those ending in *au* take *x* in the plural; as *beau*, fine, *beaux.*

Those ending in *al* change *al* into *aux*; as *égal*, equal,

NATURAL PHILOSOPHY.

MECHANICAL POWERS — THE LEVER, WHEEL & AXLE.



égaux; but most of these adjectives have no plural masculine; as *austral, boréal, canonial, conjugal, diamétral, fatal, filial, final, frugal, jovial, lustral, matinal, naval, pastoral, pectoral, spécial,* and *vénal.*

The adjective *tout,* all, makes *tous* in the masculine and *toutes* in the feminine.

Adjectives relating to several nouns, even though each noun should be singular, agree with them all taken together, and must therefore be put in the plural.

So if all the nouns are masculine, put the adjective in the masculine plural; as *Le frère, l'oncle, le neveu, et le père sont grands,* The brother, the uncle, the nephew, and the father are tall.

If all the nouns are feminine, put the adjective in the feminine plural; as *La sœur, la tante, et la mère sont intéressantes,* The sister, the aunt, and the mother are interesting.

If of several nouns any one is masculine, even although all the others may be feminine, the adjective must be put in the masculine plural; as *Le frère, la tante, et la mère sont charmants,* The brother, the aunt, and the mother are charming.

COMPARISON OF ADJECTIVES.

Adjectives have three degrees of signification—the positive, the comparative, and the superlative.

The *positive* is simply the adjective without any increase or diminution ; as *grand,* large.

The *comparative* is the adjective denoting comparison between two persons or things ; and as an object can be either *superior, equal,* or *inferior* to another, there are three kinds of comparatives :—

1. To express the comparative of *superiority* put *plus,* more, before the positive, and *que,* than, after it; as *Il est plus grand que Charles,* He is taller than Charles. Before verbs *mieux,* better, is used; as *Il a mieux fait que moi,* He has done better than I.

2. To express the comparative of *equality,* put *aussi,* as, before the positive, and *que* after it; as *Il est aussi grand que moi,* He is as tall as I.

3. To express the comparative of *inferiority,* put *moins,* less, before the positive, and *que,* than, after it; as *Il est moins grand que Jean,* He is less tall than John.

The adjective is in the *superlative* when it expresses the quality in the highest degree. There are two sorts of superlatives—the one *absolute,* the other *relative.*

1. In the *absolute superlative* no comparison is instituted between the subject and something else. It is formed by placing *le plus, le moins,* or *le mieux* before the adjective; as *Le Samedi nous sommes le moins occupés,* On Saturday we are least busy. The definite article is *invariable* in this form of the superlative.

2. In the *relative superlative* the subject is compared with something else. It is formed in the same way as the absolute superlative, but the definite article is variable; as *La rose est la plus belle des fleurs,* The rose is the fairest of the flowers.

In the superlative, when the adjective follows the noun, the article is repeated before both; as *le garçon le plus grand,* the tallest boy. When the possessive pronouns are used the article is omitted; as *mon plus grand ami,* my greatest friend.

In French there are only three adjectives which have different forms for their degrees of comparison:—

Positive.		*Comparative.*		*Superlative.*	
Bon,	*good.*	meilleur,	*better.*	le meilleur,	*the best.*
Mauvais,	*bad.*	pire,	*worse.*	le pire,	*the worst.*
Petit,	*little.*	moindre,	*less.*	le moindre,	*the least.*

The following adverbs, which mark these three degrees of comparison, are repeated before each adjective when several are joined to the same noun, and are followed by the conjunction *que,* meaning than or as:—

Positive.		*Comparative.*		*Superlative.*	
Bien,	*well.*	mieux,	*better.*	le mieux,	*the best.*
Mal,	*bad.*	pis,	*worse.*	le pis,	*the worst.*
Peu,	*little.*	moins,	*less.*	le moins,	*the least.*

The French say also *plus mauvais, plus petit, plus mal;* but never *plus bon, plus bien, plus peu.*

The meaning of adjectives or adverbs is often strengthened by placing before them the words *très, fort, bien,* meaning very, or *extrêmement, infiniment,* &c. These words are invariable, and must be repeated before each adjective; as *Les sœurs étaient fort jeunes et fort petites,* The sisters were very young and very small.

Besides carefully studying the examples given above along with the rules, the student should make himself so acquainted with the following sentences that on looking at the English he can at once give the French for it:—

Rufin était aussi méchant qu'Eutrope,	*Ruffinus was as wicked as Eutropius.*
Le bien est plus ancien que le mal,	*Good is older than evil.*
La mort est moins funeste que la honte.	*Death is less fatal than shame.*
L'orange est plus douce que l'abricot,	*The orange is sweeter than the apricot.*
L'abricot est moins doux que l'orange,	*The apricot is less sweet than the orange.*
Nous avons vu une noix aussi grosse qu'un abricot, mais plus petite qu'une orange,	*We have seen a nut as big as an apricot, but smaller than an orange.*
La charité est une très-belle vertu,	*Charity is a very admirable virtue.*
Dieu est infiniment bon,	*God is infinitely good.*
Voilà la femme la plus gracieuse que je connaisse,	*There is the most kindly woman I know.*
Elle est la moins jolie des trois sœurs,	*She is the least pretty of three sisters.*
C'est le meilleur homme du monde,	*He is the best man in the world.*
Au moindre signe vous serez obéi,	*At the slightest sign you shall be obeyed.*
Le désespoir est le pire de tous les maux,	*Despair is the worst of all evils.*
Il m'avait donné son plus beau chapeau,	*He had given me his most handsome hat.*

NATURAL PHILOSOPHY.—CHAPTER VI.

THE MECHANICAL POWERS: THE LEVER—WHEEL AND AXLE—PULLEY.

In moving a body of a certain weight through a certain space, it is rarely desirable to apply directly the available force. The assistance of mechanical power is therefore required to supply the force in a condition suitable for producing the desired effect. The object of all machinery being to transmit force, and diffuse or concentrate it in one or more points of action, the various divided or concentrated forces, being all added together, will amount to the original available force. Every machine when analyzed will be found to consist of a combination of six simple mechanical elements or machines, commonly called the mechanical powers, although they simply transmit and diffuse, or concentrate force or power.

These simple elements are—the *lever,* the *wheel and axle,* the *pulley,* the *inclined plane,* the *wedge,* and *the screw.* In order, therefore, to understand the nature of any machine, a correct knowledge of these elements is requisite.

The *lever* is the name given to any inflexible bar, A B, A′ B′, straight or curved (figs. 1 and 2, Plate II.), resting upon a fixed point or edge, F, called the *fulcrum ;* and the forces acting upon the lever are the *weight* or *resistance,* W, the *power,* P, and the *reaction* of the fulcrum.

Let A G B (fig. 1) represent a horizontal bar without weight, moving in a vertical plane about the fulcrum F, and let the power P, acting vertically at A, support the weight W, suspended at B. The principle of the lever, therefore, requires to produce equilibrium, that $P \times AF = W \times FB$; that is, the moment of P depends on the product of P and AF, that is, on $P \times AF$; and similarly $W \times FB$ represents the moment of the force W round the axis through F. The principle of the lever asserts that these moments are equal when the forces balance. This rule is determined by the circumstance that a uniform cylindrical rod will balance when supported upon its middle point. The bar A B (fig. 3) will also be in equilibrium so long as the product of the weights P, P', P'', multiplied into their

respective distances from the fulcrum F, are equal to the product of W, W′, W″, multiplied into their respective distances from the fulcrum F; for $P \times AF = W \times BF$; $P' \times A'F = W' \times B'F$, and $P'' + A''F = W'' \times B''F$, and the bar AB is therefore in equilibrium on the fulcrum F.

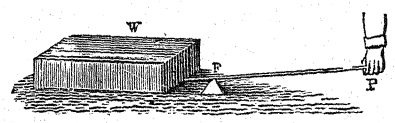
The fulcrum may be either between the power and the weight, or outside both. This circumstance gives three varieties of levers—

First, when the fulcrum lies *between* the power and the resistance;

Second, when the fulcrum lies *outside the resistance;* and,

Third, when it lies *outside the power.*

The lever of the first order is represented in annexed cut in the operation of raising a heavy stone, where FP is a



straight iron bar, working on the fulcrum F, the power being applied at P, and the resistance to be overcome is the stone W. Other instances of the same kind are the common balance, the steelyard (fig. 4, Plate II.), and the poker when used to stir the fire; in the latter case the fuel is the resistance, the bar of the grate the fulcrum, and the pressure of the hand the power. A pair of scissors, also, is an example when cutting any resisting material.

The lever of the second order (fig. 5, Plate II.), in which the fulcrum is outside the weight, is exemplified by a man holding a wheelbarrow: the axle of the wheel is the fulcrum, the load on the barrow the weight to be raised, and the force of the hands acting at the other extremity of the barrow is the power. The starting handle of a locomotive engine is another instance, where the rod that communicates motion to the valve gear is jointed to the handle between the pivot which is below and the upper end of the handle to which the power is applied. Again, the blowing of a pair of bellows is another example; the leather hinge at the root of the nozzle is the fulcrum, the air within and without offers the resistance to opening and shutting, and the effort of the hand at the other end to overcome the resistance is the power employed.

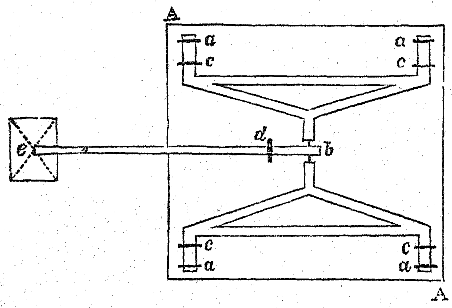
The third order of lever (fig. 6, Plate II.), or that where the fulcrum is next the power outside, is illustrated in opening and closing a gate by applying the hand near the hinges; for here the hinge is the fulcrum, the body of the gate is the resistance to be moved, and the force of the hand is the power. The lever of the third order is also very much employed in the mechanical movements existing in the bodies of animals.

As the lever is a straight line on which three forces act perpendicularly—namely, the power, the weight, and the reaction of the fulcrum—two of them must be opposed to the third, which must act between them, and the middle force is always equal to the sum of the two outside forces. From this the amount of resistance offered by the fulcrum may always be ascertained. The conditions of equilibrium in a bent lever, A′FB′ (fig. 2, Plate II.), are at once deduced from that of a straight lever where the equality of moments balance, and all problems upon the bent lever are solved by one uniform method. Thus A′FB′ represents a bent lever acted upon by forces P and W; therefore the moment of P is $P \times A'F$, the moment of W is $W \times B'F$, and the condition of equilibrium is that these moments shall be equal, or that $P \times A'F = W \times B'F$; draw the lines $A'a$ and $B'b$ at right angles to PA′ and WB′, and a line ab perpendicular to both through F. By the principle of the transmission of force, P and W may be transferred from A′ and B′ to A and B respectively, and the condition of equilibrium for the lever AFB will still be $P \times AF = W \times FB$. This proposition includes also the case of the straight lever, where the forces act obliquely to the arms, and where the same law of the equality of moments holds good. This is shown in fig. 7. Although the levers have been separated into three orders—one where the fulcrum is between the power and the weight, and the other two where the power and the weight are on the same side of the fulcrum —this distinction is of no practical value, as the turning effect of a force is represented by its moment, and the position of the fulcrum being ascertained, the subject is practically exhausted. The ordinary balance is the most common application of the lever with equal arms. When the power and the weight are at equal distances from the fulcrum, they must be equal to one another to induce equilibrium; and thus a means of testing the weights of quantities is afforded. If the two arms be not of perfectly equal length, a small weight at the end of the longer will balance a greater weight at the end of the shorter. An excess of half an inch in the length of a beam arm to which grocery is hung, and which should be 8 inches long, would defraud the purchaser of very nearly an ounce out of every pound. A good balance ought to satisfy the following conditions:—*The two arms of the beam should be exactly equal.* To test whether the arms of the beam are equal, weights are placed in the two scales until the beam becomes horizontal, then by changing the weights into the opposite scales the beam will remain horizontal if its arms are equal, but if unequal it will descend on the side of the longer arm. *The balance ought to be in equilibrium when the scales are empty,* otherwise unequal weights must be placed in the scales to produce equilibrium; still the arms are not necessarily equal, even though the beam remain horizontal when the scales are empty; for this result would be produced if one arm were longer, provided a lighter scale at that end were suspended to it. Again, *the beam being horizontal, its centre of gravity ought to be in the same vertical line with the edge of the fulcrum, and a little below the latter,* otherwise the beam would not be in stable equilibrium. The exact weight of a body may be determined, even if the balance be not perfectly true, by placing it successively in the two scales of the balance, and then deducing its true weight; for instance, place the body to be weighed, whose true weight is x, in one scale, in the other the weight, w, required to balance it; and let a and b be the arms of the beam corresponding to x and w. Then, from the principle of the lever, $ax = wb$. Again, if w is the weight when the body is placed in the other scale, then $bx = aw$, therefore $abx^2 = abww$, or $x = \sqrt{ww}$. This is known as Borda's method.

The steelyard is a simple lever, AB (as shown in fig. 4, Plate II.), about 20 inches long, having its fulcrum, F, near one end; on to its short arm, BF, a scale is hung suspended by the pivot B, into which the substance, W, to be weighed is placed. On the longer arm, FA, a sliding weight, P, is hung, which, by being shifted to various distances from the fulcrum, as D or D′, balances articles of various weights in the scale W. In order to compensate the weight of the lever, the shorter arm is enlarged and weighted with the hook or scale, so that BF preponderates over the arm FA, and it becomes necessary to hang the weight P at a point, E, very near to the fulcrum F, to keep the lever in equilibrium. Let x be the weight of the whole lever, together with the hook or scale, c their common centre of gravity; then x at c balances P at E, therefore $x \times cF = P \times FE$. Now let P at D balance W at B, then $P \times DF = W \times BF + x \times cF = W \times BF + P \times EF$. Therefore $P(DF - cF) = W \times BF$, or $P = \frac{W \times BF}{ED}$. Let W weigh 1 lb., then $ED = \frac{BF}{P}$; or if W weigh 2 lbs., then $ED = \frac{2BF}{P}$ and so on. Usually the graduations begin at ½ and go up to 14 lbs. The steelyard is then reversed, and hangs from a new fulcrum much closer to B, enabling the graduation to be continued from 14 lbs. to 57 lbs.; the intervals corresponding to a difference of weight equal to 1 lb. are now much nearer together, the arm BF being shorter.

The rules which determine the condition of equilibrium in the simple lever are also applicable for the same purpose in a combination of levers. If the short end of a lever, AB (fig. 8, Plate II.), which makes 1 lb. at A balance 3 lbs. at B, be applied to the long arm A′ of another lever, A′B′, which does the same, then 1 lb. at A will balance 9 lbs. at B′, the short arm of the second lever, and by applying the second to a third lever, A″B″, of the same proportions, three times nine, or 27 lbs. at B″ will be balanced by 1 lb. at A. The cart-weighing

machine here shown in plan presents an elegant combination of levers, by which the proportion of the power is to the weight, when balanced, generally as 1 to 28, or 4 lbs. to the hundredweight. A A is a square frame fitted for the reception of the apparatus. *a a a a* are four fulcra fixed at the four corners, on which the two triangular levers, *a a b*, *a a b*, rest by their extremities. Each lever has thus two fulcra, which

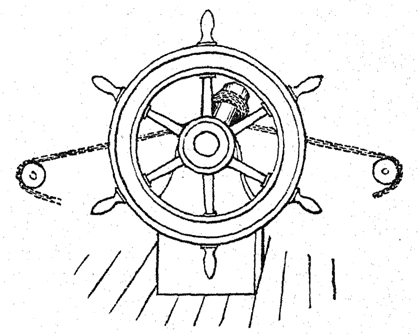


may therefore be regarded as two levers combined into one at *b*. At the points, *c c c c*, 5 inches from *a*, the top plate, which receives the load to be weighed, rests by four legs. Therefore the pressure of the load is communicated by the four corners to the extremities, *b*, of the levers, which are 20 inches perpendicular distance from *a a* and *c*. These are suspended by links to a steel centre fixed at *b* in the lever *b d e*. The distance, *b d*, from the fulcrum is 6 inches, and *d e* is 42 inches, the scale for the weight being hung at *e*. To calculate, therefore, the proportion of the power to the weight to be balanced, the levers *a a b* are of the second class, the weight being between the fulcrum and the power; and the respective distances of the weight and the power from the fulcrum are 5 and 20, or as 1 to 4, so that the balancing effort at *b* is one-fourth of the whole load. Again the lever *b d e* is one of the first-class, for its fulcrum, *d*, is in the middle, and its distances from the points *b* and *e* are 6 and 42 inches, or in the proportion of 1 to 7, showing that a force at *b* will be balanced by one-seventh of itself at *e*. Now the force at *b* is one-fourth part of the load, so that the force at *e* necessary to balance it will be one-seventh of one-fourth of the load, or $\frac{1}{28}$, which represents 4 lbs. on the scale for every hundredweight on the table. The weight of the moving parts of the machine is necessarily balanced by counterweights.

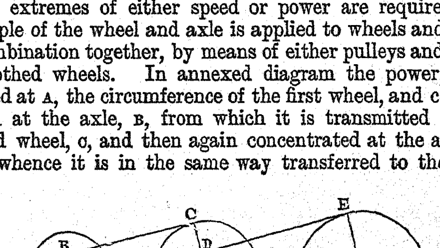
WHEEL AND AXLE.

The importance of the wheel and axle as a mechanical power is very great, as it presents a means of transmitting rotatory motion from one piece of machinery to another, or of raising a weight with a greater or less velocity to any given height. The wheel and axle may be described as an arrangement by which the action of a lever is continued for any given length of time, and the power is applied tangentially on the wheel, and the resistance tangentially to the axle, so that the radii of the wheel and axle respectively become the arms of the lever. Therefore, when the power is to the resistance as the radius of the axle is to the radius of the wheel, equilibrium will be established. This is illustrated in fig. 9, Plate II., where P is the power and W the weight, so that $P : W :: CA : CB$, or $P \times CB = W \times CA$, or $\frac{P}{W} = \frac{\text{radius of axle}}{\text{radius of wheel}}$; and as B C and C A lie in the same line, although in different planes, they may be regarded as a lever, B C A, the fulcrum of which is C. The same conditions of equilibrium will apply to the machine, and therefore if the weights P and W balance each other on the pulleys, the products obtained by multiplying these weights by their distances respectively from the centre C will be equal. Consequently, if W be 90 lbs., and A C be 6 inches, then $90 \times 6 = 540$, which is the moment of the weight, and by dividing 540 by the distance C D (say 18 in radius), or $540 \div 18 = 30$ lbs.; so that a power of 30 lbs. applied at B will balance 90 lbs. acting at A, or the power and the weight are to each other *inversely* as their distances from the centre.

A common application of the wheel and axle is the windlass for raising water in buckets from draw-wells (fig. 10, Plate II.) Here the power P is applied to the handle, which therefore represents the lever of the wheel, and the bucket W the weight to be raised by the axle. Another example of the wheel and axle is shown at fig. 11, in which the power P may be applied either to the ends of the bars S S S, or to a rope, I, coiled round the circumference of the wheel to raise the weight, W. The ratchet and click, G, fixed on to the axle at D, is introduced to sustain the weight, W, in any given position on releasing the power, P. The steering-wheel is another example of the application of the wheel and axle. In this case the handles by which the wheel is turned are projected through the rim; the chain is wrapped several times round the axle



and led off on either side round pulleys for attachment to the lever acting upon the rudder. The steersman, by laying hold of the handles, turns the wheel, and so either winds or unwinds the chain on either side to act upon the lever of the helm, according to the direction in which he turns the wheel. When extremes of either speed or power are required, the principle of the wheel and axle is applied to wheels and axles in combination together, by means of either pulleys and belts, or toothed wheels. In annexed diagram the power, P, is applied at A, the circumference of the first wheel, and concentrated at the axle, B, from which it is transmitted to the second wheel, C, and then again concentrated at the axle, D, from whence it is in the same way transferred to the third

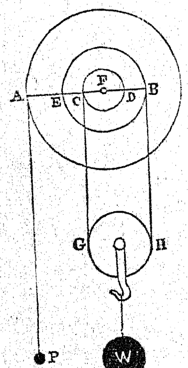


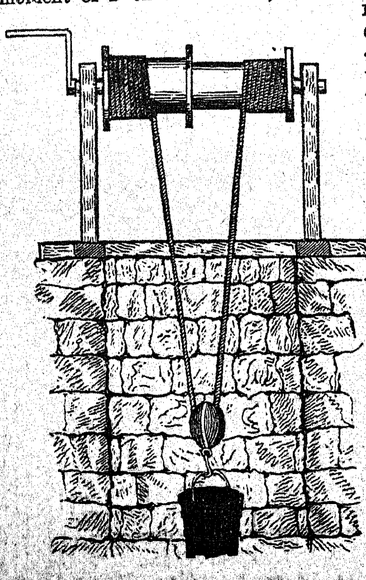
wheel, E, at the axle, K, of which the weight, W, acts. In this illustration the belts, B C and D E, are simply the means of transmitting the force from wheel to wheel. The proportions of the diameters of the axles, B, D, K, to the diameters of the corresponding wheels, A, C, E, therefore determines the force, P, necessary to raise the weight, W. The force P, at A, is to the force transmitted along B C to C, as B F to F A; the force C is to the force transmitted along D E to E, as D G to C G; and the force at E is to the force at K, or the weight W, as H K to H E. Therefore if the force P be 6 lbs., and the wheels, A, C, E, respectively 18, 25, and 32 inches diameter, and the pulleys or axles, B, D, K, have a diameter of 6, 5, and 8 inches respectively, the gain of the first wheel and axle will be as 1 to 3, and the force transmitted to C is 18 lbs. In the second wheel the proportions are as 1 to 5, so that the force transmitted to E is five times that at C, or fifteen times the force at A, or $5 \times 18 = 90$ lbs. This force is again concentrated at the third axle, K, in the proportions of the diameters, or 1 to 4, which is four times that at E, and sixty times that of A, or $4 \times 90 = 360$, which is the ultimate weight, W. If, instead of multiplying the several proportions together, the diameters

themselves had been used in expressing their proportions and multiplying them together, the same result will be obtained. Thus :—

6	to	18
5	to	25
8	to	32
240		14400

which is in the proportion of 1 to 60. Hence the rule to find the proportion between the power and the weight in a combination of wheels and axles is—*Multiply the diameters of the axles together, and also the diameters of the wheels; the proportion of the products is that of the power and the weight.* An arrangement for increasing the power of the single wheel and axle is shown in annexed cut, in which the weight acting on both sides of the centre of motion nearly balances itself, leaving only a small portion of it to be compensated by the power applied. The outer circle represents the wheel, the power P acting at the circumference at A. The axle is composed of two rollers of unequal diameters, B and D, fixed on the same centre F, the cross sections of which are B E F, and D C. The weight W hangs by the pulley G H, round which the rope passes, the two ends being coiled round the two rollers B, D, in opposite directions, so that the rope hangs from the smaller at C on the same side with the power, and from the larger on the opposite side at B. As the weight W is divided between the ropes C G and B H, the more nearly the rollers C D and E B are equal in diameter, the less will be the power required to make the equilibrium. In this way a very small power P may balance a very heavy weight, for the moment of force at B is half W × B F; and the moment of force at C is half W × C F or by D F, which is equal to C F. Therefore, as the moments of force at C and B are opposed to one another, their difference is the product of half W multiplied by the difference of B F and D F, that is, B D, which represents the unbalanced quantity. Therefore, P × A F must equal half W multiplied by B D, or P : W :: B D : 2 A F, or the diameter of the wheel. For example, if F B is 12 inches, F C 8 inches, F A 24 inches, and the weight of W and pulley G H 900 lbs., and the weight on each cord therefore 450 lbs.; then, the moment of B on the side F B, is 450 × 12 = 5400; and the moment of C, on the other side F C, is 450 × 8 = 3600; and the difference of these moments, which is to be counteracted, is 1800. Therefore the *weight* in lbs. necessary to be applied at A (F A being 24 inches) is 1800 divided by 24, or 75 lbs.; therefore the weight sustained, 900 lbs., is twenty-four times as great as the power employed to balance it. Or P : W :: B D : 2 A F; that is, 75 : 900 :: 4 : 48. A wheel and axle for drawing water constructed upon the principle explained, is shown in the annexed cut.

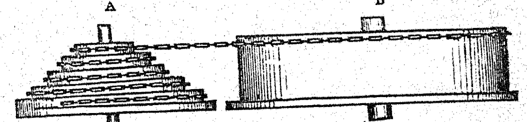




When toothed wheels are employed as the gearing connecting the wheels and axles together, the calculations are upon the same principle, as each toothed wheel of a train is the *mechanical equivalent* for the arm of a lever continuously in action. Fig. 12, Plate II., illustrates the gearing together by toothed wheels of the wheels and axles A, B, C, in combination, where P is the power and W the weight to be raised. Another form of toothed gearing, as applied to the single wheel and axle, when a heavy weight has to be raised, is shown at fig. 10, Plate III. Here the rotation of the wheel is caused by the revolution of the endless screw fixed upon the spindle C B, working into the teeth of the wheel F D. The power is applied at A; the weight to be raised is W. In order to raise the weight W a power p must be applied at the circumference of the wheel such that $p = W\frac{r}{R}$, in which r and R are the radii of the axle and of the toothed wheel respectively. The rotation of the wheel F D is effected by means of the endless screw, the teeth of which fit in those of the wheel F D; but if this endless screw is to exert at its circumference a power p, the power P which is applied at the end of the handle must be $P = \frac{r'}{R'}p$, in which r' is the radius of the screw, and R' the length of a lever at the end of which P acts; therefore $P = \frac{r r'}{R R'}W$.

If a constant resistance has to be overcome by a variable force, it is evident that to overcome the resistance with a uniform effect at all times, the power must act at different distances from the axis, or rather the distance from the centre must be *increased* or *diminished* exactly as the power *diminishes* or *increases*, the moment of the power being thus constant. When the power varies uniformly, as from the uncoiling of a spring, a barrel of a conical form is employed. The *fusee* of the common watch is an instance of this form of wheel and axle, by which the reduction of the force of the spring as it uncoils is compensated by the increasing radius of the fusee. This arrangement is shown in cut. To obtain

A B



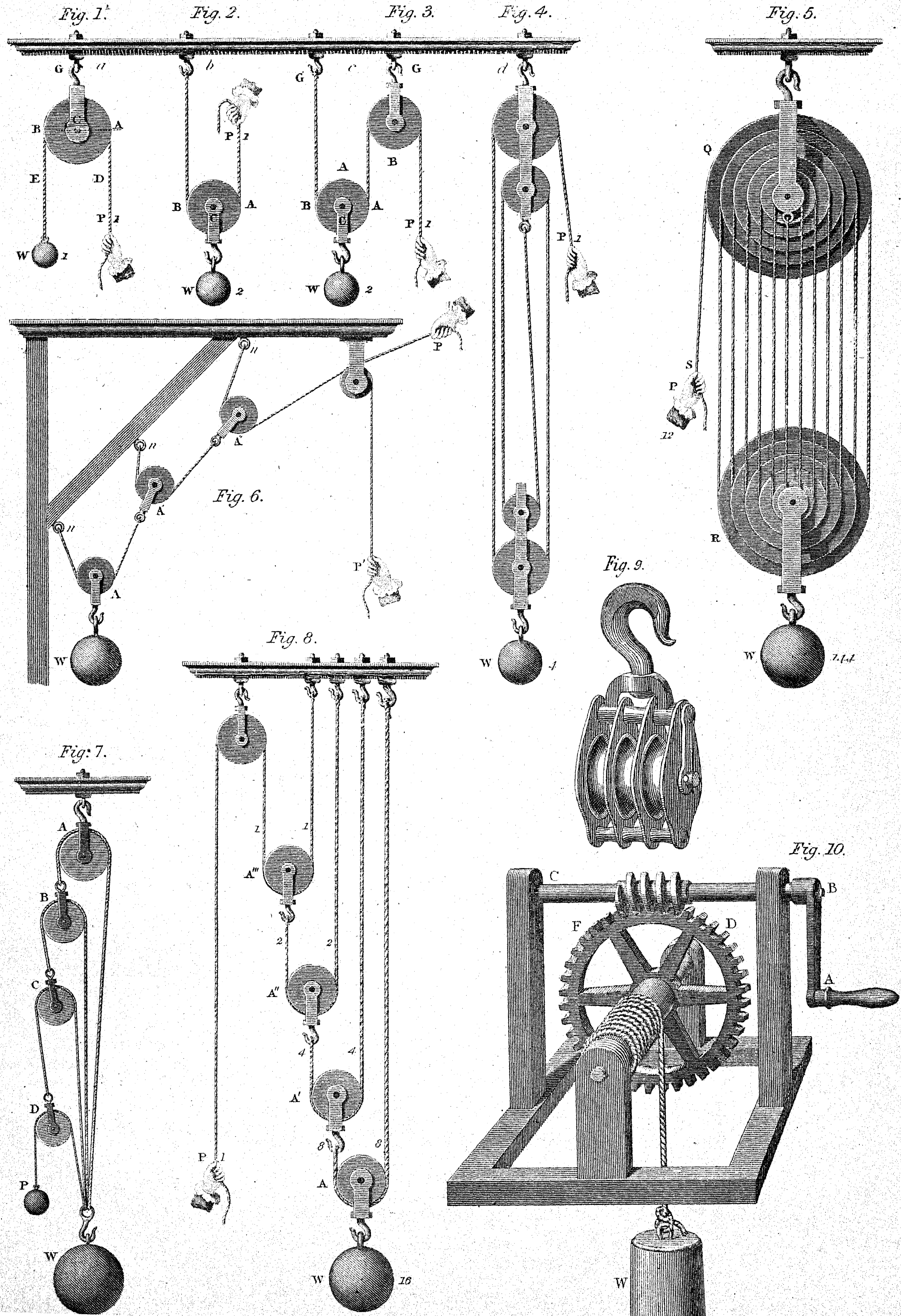
a uniform force from the spring coiled up in the barrel B, the chain, when the spring is at its highest tension, is wound upon the smallest radius of the fusee A. The spring as it uncoils turns the barrel B, and carries the chain off the fusee at a gradually increasing distance from the centre, so that the leverage increases in the same proportion that its elastic force decreases. In all constructions of the wheel and axle in which the effect is produced by the winding of a rope on an axle, when the rope has coiled round the whole length of the axle and returns over itself, it will act at a distance from the centre increased by its diameter. This source of variation of the radius of the axle increases the difficulty of raising weights the higher they are raised. For example, in a rope of 2 inches diameter turning on an axle 12 inches diameter, the radius is *half the rope* + half the axle, or 7 inches, and, when coiled over itself on the same axle, the radius will be 2 inches more, or 9 inches.

THE PULLEY.

The elements of machinery may be, in general principles, reduced to two, the *lever* and the *inclined plane;* for though they vary essentially in the particular arrangement of their parts, yet they may all be resolved into two general principles of action, which are most simply represented in the action of the lever and of the inclined plane. Thus the pulley and the wheel and axle are directly modifications of the lever, and their action may be calculated on its principles; the wedge and the screw are in like manner modified inclined planes. The principle of equality of moments is that on which the action of the lever is founded; and it supposes a centre of motion, while the action of the inclined plane is a case of the composition and resolution of

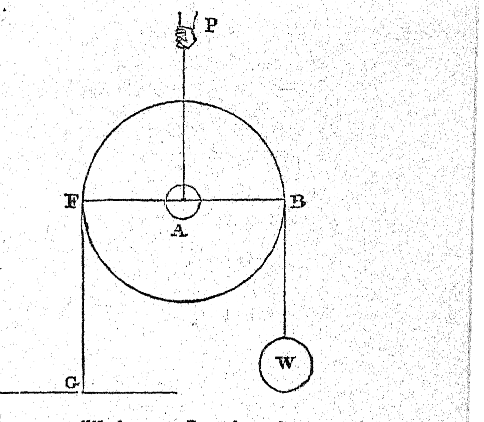
NATURAL PHILOSOPHY.

MECHANICAL POWERS — THE PULLEY &c.



forces by the triangle, and does not imply any centre of motion; so that the existence and non-existence of a centre of motion are the distinguishing characteristics of the two general elements of machinery. In ordinary cases of the lever, where a motion round a centre is required only through a small space, the ordinary beam or bar does sufficiently well, as in the instance of the pump handle, the weighing machine, and the more complex cart-weighing platform; but when a continued motion is required to be transmitted from one centre to another, there must be a constant succession of levers working on two centres, and coming by successive pairs into contact. Wheels with teeth on their rims are simply systems of levers which, by working into one another, communicate a continued rotatory motion from one centre to another. A wheel, generally constructed of hard wood, brass, or iron, with a groove in its circumference for the reception of a rope or chain, and which can turn freely on an axis in the centre, forms a *pulley*, and its object when fixed by the centre, or used singly, is to change the direction of a rope or chain for the more convenient application of the power. In fig. 1, Plate III., the pulley is stayed at the centre C, and attached to a beam above by the stirrup C a; the weight, W, is drawn upward by the downward force of the power P, which is connected to it by a rope passing over the circumference of the pulley. The centre, C, of the pulley being fixed by the stirrup C a, is also the centre of motion, and therefore if lines be drawn to it from the points A B, at which the rope leaves the pulley, these lines, A C, C B, being the distances from the centre at which the power and the weight act, form a lever by which the power acts upon the weight; and as A C, C B, are of equal lengths, they form a lever of equal arms, and therefore also the power and the weight are equal; and if P represents 1, W represents 1, or P=W. In the course of one revolution every point in the circumference will arrive at the positions A, B, and so in its turn be the extremity of a lever consisting of two radii. The fixed pulley therefore affords no mechanical advantage, but is simply convenient in changing the direction in which the power is applied. The principle of the reduplication of power by a combination of pulleys, where the pull of a stretched rope comes into action several times, instead of only once, explains the advantage gained by the use of the pulley in lifting weights, &c. If several pulleys are joined together on a common axis which is fixed, and a rope passes round all these and also round a similar but movable combination of pulleys, such an arrangement is called a *block and tackle*. If the weight W, which is attached to the hook common to the system, is supported by, say, six portions of rope passing over a combination of three pulleys, which is called a *treble* block, it is supported by the six portions of the rope, and each of these portions will sustain one-sixth of the weight; and the power P, which is applied at the free end of the rope which passes over the upper pulley, will have the same value, and will support also one-sixth of the weight W. Therefore the relation between the power and the weight in a block and tackle is expressed by $P=\frac{W}{n}$, in which n is the number of ropes by which the weight is supported.

The single fixed pulley is a universal lever of the first kind, the centre of the pulley being the fulcrum; the pulley, however, may also be employed as a lever of the second and third kind by altering the circumstances. The second kind of lever is that in which the resistance is between the fulcrum and the power. For instance, the weight W (fig. 2, Plate III.) is suspended by the centre of the pulley, one end of the rope being fixed at b, and the power applied at the other end P; the point b becomes the fulcrum of the lever A B, and the power being applied at A, the distance A B is twice the distance of B from the centre of the pulley. As the power therefore acts at double the distance that the weight does from the fulcrum, it will be only one-half the weight, and equality of moments is produced; that is, $B \times AB = W \times BC$, the centre of the pulley being C; in other words, a power of 1 lb. is sufficient to balance a weight of 2 lbs. when suspended from the axis of the pulley, or $W=2P$; if, instead of being parallel and vertical, the two portions of the rope are inclined at an angle, a, the equation will be $W=2P\cos\frac{a}{2}$. The movable pulley is therefore a lever of the second kind, in which the resistance to be overcome is at an equal distance from the fulcrum and the point of application of the power. The annexed diagram shows the application of the pulley to a lever of the third kind, in which the power is applied between the fulcrum and the weight. For by passing a rope over the pulley and fixing it below at G, with the weight W at the other end, and applying the power P at the centre A, the fulcrum will be F, which will be one-half the distance between the fulcrum and the weight F B; that is, $AF=\frac{1}{2}BF$, consequently the power must be double the weight to produce equilibrium.



In the three examples given, the pressure acting on the centre of the pulley is between the other two at the circumference of the pulley, and being always opposite to them, is equal to their sum. As the pressures at the circumferences are produced by the action of equal forces, they are equal to one another; from this principle the relation of the power to the weight is calculated in single pulleys. The application of the pulley to the purposes of a lever of the third kind is rarely made in practice; so that all combinations of pulleys into systems are composed of the first and second kind. Fig. 3, Plate III., shows a combination of two pulleys in which there are two fixed points, c, serving as fulcra for the pulley carrying the weight W of the second kind, and the fixed pulley of the first kind, which simply returns the rope downward for the convenient application of the power P. As the movable pulley A B enables a power of one-half to overcome the weight suspended, the pressure upon the fulcrum of the fixed pulley will be one-half of W, and that at the circumference of the pulley will also be one-half the weight W; and the power P will be one-half of W, or a force of 1 lb. at P will sustain a weight of 2 lbs. at W, or W=2 P. Another form of pulleys in combination is shown (fig. 7) where there are four pulleys, A B C D, attached by cords to W, the deviation of which from a vertical line is so small that it is not taken into consideration. If the weight W be 16 lbs., the pressure on B will be 8 lbs., on C 4 lbs., the pressure on D 2 lbs., and that on W will be 2 lbs. + P or 3 lbs.; therefore, a power of 3 lbs. applied at P will sustain 16 lbs. at W. A combination of movable pulleys is also shown in fig. 8, by which additional power is gained. A A′ A″ A‴ are four pulleys, with four ropes fixed at one end, and connected at the other end with the pulleys above. Therefore the weight W, of 16 lbs., hanging by the lowest pulley is divided between the two parts of the rope sustaining it, producing a pressure of 8 lbs. on the centre of the second pulley A′. This pressure is in like manner divided between the two parts of its sustaining rope, and a strain of 4 lbs. comes on the centre of the third pulley A″. In the same manner the strain on the centre of the fourth pulley A‴ will be 2 lbs., giving a force of 1 lb. on one side of the fixed pulley, and an equal force on the other side for the power necessary to sustain a weight of 16 lbs. Therefore, when each pulley is suspended by a separate rope, the pull on A‴ is 2 P; the pull on A″ is 2 P+2 P, or 4 P; the pull on A′ is 4 P+4 P, or 8 P; and that on A is 16 P; therefore, $W=16P=2^nP$, where n represents the number of movable pulleys. Other arrangements of fixed and movable pulleys are shown in figs. 4 and 5. The slight deviation from the vertical in one of the ropes in the lower pulley in fig. 4, which is of no importance, may be compensated by making the radii of the pulleys in the lower block proportional to 1, 3, and those in the upper block proportional to 2, 4. By reference to fig. 4,

the number of ropes sustaining the weight is seen to be four, and therefore the weight W may be four times as great as the power P. Fig. 5 shows a combination of fixed and movable pulleys Q and R, in which the number of ropes sustaining the weight W is twelve; therefore, here the weight may be twelve times the power—or 12 lbs. at P will sustain 144 lbs. at W. The arrangement shown at fig. 4 is extremely valuable in practice; the pulleys are there threaded side by side on one axis, as shown in elevation in fig. 9: this arrangement is the common "block and tackle."

The pulleys themselves are so many additional weights which have to be considered, as they either assist P, as in the system shown in figs. 4 and 7, or are in opposition to P, as in the combination shown in figs. 6 and 8.

In fig. 7 let $w_1, w_2, w_3, \quad . \quad . \quad .$ represent the weights of the pulleys D, C, B, beginning from the lowest pulley, and let n be the number of pulleys.

Then, $W = P\,(2^n - 1) + w_1\,(2^{n-1} - 1) + w_2\,(2^{n-2} - 1) + \; . \; . \; . \; w_n - 1$.

In fig. 8, the weight of the lower pulleys is added to make part of the load W. Let $w_1, w_2, w_3, \quad . \quad . \quad .$ be the weights of the pulleys A, A′, A″, beginning from the lowest pulley, and let n be the number of movable pulleys.

Then $2^n P = W + w_1 + 2w_2 + 2^2 w_3 + \quad . \quad . \quad . \quad + 2^{n-1} w_n$.

ARITHMETIC.—CHAPTER III.

MULTIPLICATION OF WHOLE NUMBERS.

MULTIPLICATION (Lat. *multus*, many, and *plico*, I fold) is the adding together into one sum a series (more or less numerous) of similar numbers. The idea conveyed by it is that of a long slip, on which there is written, in distinct spaces, the definite similar number which is to be repeated any given number of times; each space is then folded over and over until the whole are folded up together, and on the outside there is written the sum or total of the numbers contained in this manifolded slip. This is easily shown to be the case by taking a strip of paper, say one yard long, and writing upon each inch's space a fixed similar number; for example, 6. That would give 6 repeated thirty-six times. Fold up this paper, inch by inch, taking note as each 6 is folded out of sight how much the amount increases, until all is formed into a small solid set of foldings, on the upper side of which a note of the entire enumeration should be made. This would show that all the 6's added together formed in sum 216. Another, and perhaps even a simpler plan, is to take a paper of pins, put up in dozens, and see how, when twelve of these rows have been folded up and note is made of the whole number of pins thus folded in their rows, that their sum is $12 \times 12 = 144$.

Multiplication is the process by which such repeated additions of similar numbers are easily and concisely made. Thus, supposing there are 7 heaps of pebbles, and 23 pebbles in each heap, and it is required to find out how many pebbles there are in all the heaps, we would put the following question—what is 23 counted 7 times; in other words, what is 23 *multiplied* by 7? To answer this question we write 23 *seven* times, and make the addition as in the margin, which gives 161 as their sum. In such a question, 161 is called the *product* of 7 and 23, and 7 and 23 are the *factors* of that product. Again, 23 is called the *multiplicand*, and 7 the *multiplier;* and in all cases where a product is found in this way, the operation is called *multiplication.*

$$\begin{array}{r} 23 \\ 23 \\ 23 \\ 23 \\ 23 \\ 23 \\ 23 \\ \hline 161 \end{array}$$

Were there no questions in arithmetic more difficult than these, there would be little need for any shorter method than that shown above. But if there were 2767 heaps of pebbles, and 8967 in each heap, the labour of addition would be truly terrible: we would require to write 8967 two thousand seven hundred and sixty-seven times, and add up all these enormous columns. Multiplication has been invented to shorten this process by separating it into a certain number of partial operations, each of which may be performed with facility.

We know already, from what we have learned in addition, that to find any sum, however great, it is only necessary to be able to tell with readiness the sum of any numbers under 10. The case is similar in multiplication. The chief difficulty to be encountered and surmounted is the learning of the *products* of all numbers under 10, that is, up to 9 times 9 inclusive. These products are shown in the following table, all the parts of which inclosed by the bold black lines it is *absolutely necessary to commit accurately to memory*, and it will be found highly advisable to learn the whole of it.

MULTIPLICATION TABLE.

Multiplicands.	2	3	4	5	6	7	8	9	10	11	12
Multipliers.	Products.										
2	**4**	6	8	10	12	14	16	18	20	22	24
3	6	**9**	12	15	18	21	24	27	30	33	36
4	8	12	**16**	20	24	28	32	36	40	44	48
5	10	15	20	**25**	30	35	40	45	50	55	60
6	12	18	24	30	**36**	42	48	54	60	66	72
7	14	21	28	35	42	**49**	56	63	70	77	84
8	16	24	32	40	48	56	**64**	72	80	88	96
9	18	27	36	45	54	63	72	**81**	90	99	108
10	20	30	40	50	60	70	80	90	**100**	110	120
11	22	33	44	55	66	77	88	99	110	**121**	132
12	24	36	48	60	72	84	96	108	120	132	**144**

A careful study of this "Mensa Pythagorica," as it was called, in recognition of the Greek philosopher who first taught the use of this simple but ingenious condensation of so many arithmetical operations—named by the Hellenic races Pinax, and by the Latins Abacus—will be amply repaid by what may be observed in its brief compass (1) As it is a table of composite numbers the prime numbers do not appear among its *products*, and hence any number omitted from these products, besides the figures 1, 2, 3, 5, such as 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, &c., may be ranked among the primes. (2) The diagonal line running from 1 to 144 in bold figures are the squares of the successive digits, 1 to 9, and onward to 12. (3) Among the products it is noticeable that 1 is the terminal figure of only *three*, 21, 81, and 121; 2 is the final in *six*, viz., 12, 22, 32, 42, 72, and 132; 3 occurs as terminal only in 33 and 63; 4 is the terminal in 14, 24, 44, 54, 64, 84, and 144; 5 is final in 15, 25, 35, 45, and 55; 6 is the closing numeral in 16, 36, 66, and 96; 7 is the last figure in 27 and 77; 8 appears as the terminal of 18, 28, 48, 88, and 108; and 9 in 49 and 99. The different proportions in which the several digits recur at the end of the products is not only curious in itself, but leads us to see that the greater proportion of the prime numbers must end in 9, 3, or 7, and the remainder in 1.

Each of the horizontal lines of the products, it will be seen, is exactly similar to each of the perpendicular ones in their order, from 2 to 12. Each line contains the product of the multiplicand over each line, and the multiplier by its side. Thus look for 7 on the top and 7 by the side, and at the angle where these two lines meet, 49, the product of the factors 7×7, will be found, and so on. All the products in this table may be readily found by addition, and perhaps the easiest way of learning it is for the pupil to make the table several times over for himself by addition: he will find this method more interesting, and will understand the nature of the table better than by conning over the dry numbers as they are here printed. He will also thus observe certain relations among the products of some of the multipliers which will afterwards help him considerably; for instance all the products by 5 terminate in 5 and 0 alternately; and in the successive products by 9 the first figure increases, and the second decreases, by 1 each time.

When we extend our observation of the foregoing table, we find that the product of 5 by 7 is the same as the product of 7 by 5—*i.e.* in both instances 35. The same observation may be made with regard to other numbers contained in the table, *e.g.* 3×6 and $6 \times 3 = 18$, 8×9 and $9 \times 8 = 72$. It will be a good exercise to gather out from the table similar combinations. From the fact thus discovered we infer that in multiplication we may invert the *order* of the *factors;* that is, we can use the multiplier for the multiplicand, and the multiplicand for the multiplier.

This may be shown as follows (where it is to be observed that we use the sign × to mean *multiplied by*, and write the multiplicand on the left of the sign, and the multiplier on the right) $5 \times 7 = 7 \times 5$—*i.e.* 35. It is obvious, as already ex-

plained, that 5×7 means nothing more than 5 repeated 7 times, and that it is sufficient for the performance of the operation to take either unit the required number of times.

Thus :—

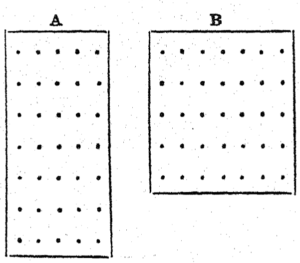
$$5 \times 7 = 7+7+7+7+7 = 35.$$

And again,

$$7 \times 5 = 5+5+5+5+5+5+5 = 35.$$

Since there is nothing to induce us to take one pair of factors rather than another, we infer that the proposition is generally true. The same fact may be represented under the following form:—

Placing 5 counters in a line, and repeating that line in all 7 times, the number of counters in all is 7 times 5, forming table A; but by reversing this table we obtain table B with 7 counters in each line, and that line repeated 5 times; the number in both tables is obviously and necessarily the same. The same method will show similar results with any other two composite numbers.



From the foregoing experiments it follows that in all cases of multiplication we may take for the multiplier whichever of the numbers we please. The fundamental principle upon which the rule for multiplication depends may be stated thus:

Any quantity is multiplied by any number when every one of its parts is taken as many times as there are units in the multiplier.

This is plain: a quantity of grain, for instance, will be doubled by doubling every bushel or every quarter of it, and a sum of money will be increased twenty-fold if every shilling of it be replaced by twenty shillings. We now proceed to apply this principle to a particular case.

Multiply 7834 by 6; that is, find the product of 7834×6. Here the multiplicand at full length is

7 thousands, 8 hundreds, 3 tens, and 4 units.

Now each of these parts being multiplied by 6 will be the product of 7834 and 6, and the result is

42 thousands, 48 hundreds, 18 tens, and 24 units.

The remaining part of the operation is to reduce the result to the customary order: to do this put down,

24 units, ...	24
18 tens, ...	180
48 hundreds, ...	4800
42 thousands, ...	42000

and, adding together these partial results, we get 47004 as the product of 7834 and 6; that is, $7834 \times 6 = 47004$.

An example will make the use of this method plain. Suppose we want to multiply 56384 by 7. Write the multiplicand and multiplier as in the margin.

```
 56384
     7
------
394688
```

Then as $4 \times 7 = 28$, put down 8 and carry 2.
$8 \times 7 = 56$, and 2 carried make 58; put down 8 and carry 5.
$3 \times 7 = 21$, and 5 carried make 26; put down 6 and carry 2.
$6 \times 7 = 42$, and 2 carried make 44; put down 4 and carry 4.
$5 \times 7 = 35$, and 4 carried make 39; which put down.

From this example it appears, that when the multiplier contains only one figure, the rule for finding the product is,

Multiply each figure of the multiplicand by the multiplier, commencing at the right; and, in so doing, jot down the right-hand figure of each partial product immediately underneath the figure which gives it, and add the left-hand figure to the next similar product: the last partial product is, of course, to be written down in full.

The following are instances of the application of this rule:

```
 36784675679      353643896734
           7                 9
------------     -------------
257492729753     3182795070606
```

The following instances may be worked in the same way:

$756 \times 7 = 5292$; $7289 \times 6 = 43734$; $4756 \times 8 = 38048$.

As explained in addition, these operations may be commenced at the left, and the carriage figures being written down must be afterwards added. The example in the margin will render this sufficiently plain. This method has some advantages, though it is certainly wanting in neatness when compared with the ordinary mode shown in the preceding examples.

```
 6483675
 6
--------
36488620
 241343
--------
38902050
```

When the multiplicand is terminated by one or more ciphers, the operation of course ought to begin only at the first significant figure; but to give the product the value which it ought to have, we must place on the right of it as many ciphers as the multiplicand contains. When ciphers are contained among the figures of the multiplicand, they yield no product, for 0 multiplied by any number however great is 0. We ought therefore, when such a case occurs, to write 0, unless there be some carriage to be added at the place. The margin presents an exemplification of such an operation.

```
 30067000
        7
---------
210469000
```

The value of a number, as we have already shown, is increased tenfold by every cipher placed on the right of it. This is only another way of saying that a number is multiplied by 10 by annexing a cipher to it, by 100 when two ciphers are annexed, by 1000 when three ciphers are annexed, and so forth. Thus, 10 times 428 is 4280; for 428 is

4 hundreds, 2 tens, and 8 units,

and taking each of these parts ten times, which is the same as multiplying the whole by 10, we get

40 hundreds, 20 tens, and 80 units,

But this is equivalent to

4 thousands, 2 hundreds, 8 tens, and 0 units,

that is 4280. In the same way we may satisfy ourselves of the correctness of this method in other cases; but the fact is made plain enough by the instances given in the following table:—

12	×	10 =	120		120	×	10 =	1200
12	×	100 =	1200		100	×	100 =	10000
12	×	1000 =	12000		3010	×	1000 =	3010000
12	×	10000 =	120000		100000	×	10000 =	1000000000

When the significant figure is different from 1—as when the multiplier is 40, 400, 4000, &c.—we can resolve the operation into two others. For 40 is 4×10, 400 is 4×100, and so on. We may also first multiply by the significant figure, and then annex the ciphers of the multiplier to the product. To take an example, let it be required to multiply 864 by 400. The operation may be arranged in either of the following modes:

```
  864          864
  400            400
------       ------
345600       345600
```

The four significant figures of the foregoing product result from the multiplication of 864 by 4; and in the first arrangement of the process, they are removed two places towards the left, to leave room for the two ciphers which terminate the multiplier. We may state the process thus:—When the multiplier is followed by any number of ciphers, we first multiply the multiplicand by the significant figure of the multiplier, and then annex, on the right of the product, the same number of ciphers as there are in the multiplier.

This is only a particular example of the following rule:— *To multiply by any number, we may multiply separately by any parts into which the number is divisible, and add the results.*

Suppose now, it is required to multiply 1061306 by 2134; since 2134 is made up of 2000, 100, 30, and 4, we may

multiply 1061306 by each of these parts, and add the products which we get.

Now, 1061306 ×	4	is	4245224
1061306 ×	30	is	31839180
1061306 ×	100	is	106130600
1061306 ×	2000	is	2122612000

We find that the sum of these is 2264827004, and this is the product sought.

As the ciphers on the right of the partial products are of no value in the addition, it is plain that they may be omitted, provided we keep the other figures in their respective places. We must observe, therefore, that were we to cancel the ciphers, the second line would be one place to the left of the first; the third one place to the left of the second, and so on; that is, the first figure of the product from the tens of the multiplier will fall under the tens of the product by the units; the first figure of the product by the hundreds of the multiplier will fall under the hundreds' place of the units' product, and so on. This being borne in mind, we might multiply the multiplicand by the successive figures of the multiplier, arranging the partial products in this way, without decomposing the multiplier into parts at all. The preceding question is shown according to this abridged method in the margin, where it will be observed that the figures of the same *local* values, that is, units, tens, hundreds, &c., all stand under one another.

1061306		
2134		
4245224	product by	4
3183918	"	3
1061306	"	1
2122612	"	2
2264827004		

This leads to the following general rule for multiplication:—

I. *Write down the multiplicand, and beneath it the multiplier, so that units may be under units, tens under tens, and so on, and draw a line so as to separate these numbers from the product.*

II. *Multiply each figure of the multiplicand by each figure of the multiplier, taking care to place the first figure of each successive product under the figure of the multiplier from which it arises.*

III. *Add the several partial products together, and the result will be the product sought.*

The following examples may now be gone over, seeing that each process is carefully compared with this rule.

3426	1300214	5554444
6234	1234	9765
13704	5200856	27772220
10278	3900642	33326664
6852	2600428	38881108
20556	1300214	49989996
21357684	1604464076	54239145660

It is often found of great practical advantage, in teaching multiplication, to have the paper or slate tesselated in squares into which only one figure may be placed. This is a pretty efficient safeguard against the misplacing of figures, and tends to the observance of the rule—units under units, tens under tens, &c. A specimen is annexed.

				3	6	9	8	5
					6	4	2	8
			2	9	5	8	8	0
			7	3	9	7	0	
	1	4	7	9	4	0		
2	2	1	9	1	0			
2	3	7	7	3	9	5	8	0

In point of fact, if we attend to the placing of the figures exactly in the rank to which their value entitles them, we may intervert the order of the partial multiplications necessary, in any way we choose, without altering the ultimate result. Of this the subjoined may be taken as an example:—

(1)

			9	5	7	
			3	4	2	
		1	9	1	4	× 2
	3	8	2	8		× 40
2	8	7	1			×300
3	2	7	2	9	4	

(2)

			9	5	7	
			3	4	2	
2	8	7	1			×300
	3	8	2	8		× 40
		1	9	1	4	× 2
3	2	7	2	9	4	

(3)

			9	5	7	
			3	4	2	
	3	8	2	8		× 40
		1	9	1	4	× 2
2	8	7	1			×300
3	2	7	2	9	4	

(4)

			9	5	7	
			3	4	2	
	3	8	2	8		× 40
2	8	7	1			×300
		1	9	1	4	× 2
3	2	7	2	9	4	

When ciphers occur at the end of both multiplicand and multiplier, they may of course be all neglected until the product of the significant figures is found, after which they must be annexed. Thus, supposing we are to multiply together 789000 and 49600, we first find the product of 789 and 496, which is 391344; then the five ciphers formerly neglected being annexed to this product, give 39134400000, which is the product sought.

When there are ciphers intermixed with the figures of the multiplier, the case is not more difficult, when the nature of the process is thoroughly understood. The following example (1) will show that the rule is a sufficient direction here as before:—

(1) Multiply 1234 by 1002001.

Here $1002001 = 1000000 + 2000 + 1$.

Then 1234 × 1	is	1234
1234 × 2000	is	2468000
1234 × 1000000	is	1234000000
The sum of which is		1236469234

=

(2)

1234
1002001
1234
2468
1234
1236469234

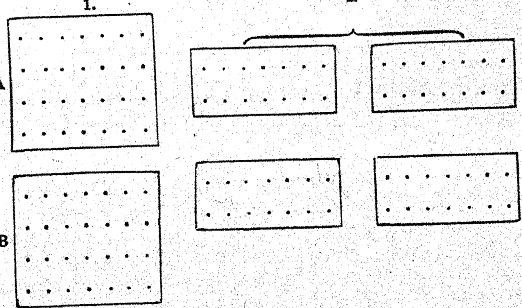
We may also arrange the figures so that (neglecting the ciphers on the right of the products as before) the operation resolves itself into the annexed form (2), in which it will be observed that the first figure of each partial product is placed immediately under the figure of the multiplier from which it results. This precaution must always receive careful attention.

There is another way in which numbers may be multiplied together, *i.e.* by submultiples or aliquot parts. Since 8 is 4 times 2, 7 times 8 may be made by multiplying 7 and 4, and then multiplying that *product* by 2. To show this, place 7 counters in a line, and repeat that line in all 8 times, as in figures 1 and 2.

1. 2.

A

B



The number of counters in all is 8 times 7, or 56. But (as in fig. 1) inclose each four rows in oblong figures, such as A and B, the number in each oblong is 4 times 7, or 28, and there are two of these oblongs; so that, in the whole, the number of counters is twice 28, or 28×2, or 7 first multiplied by 4, and that product by 2. Fig. 2 shows 7 multiplied by 2, and that product by 4. The same method may be used with other composite numbers. Thus, since 72 is 8 times 9, then will 72 times 789 be 8 times 789 and

that product multiplied by 9. If we use the signs the foregoing statements will stand thus:—

$$7\times 8 = 7\times 4\times 2 = 7\times 2\times 4.$$
$$789\times 72 = 789\times 8\times 9 = 789\times 9\times 8.$$

(This illustration is taken from A. De Morgan's "Elements of Arithmetic.")

This principle will hereafter be found of great use: it is the foundation of the common rule for multiplying by *composite numbers;* that is, numbers composed of two or more factors, *e.g.* $15=3\times 5$; $21=7\times 3$; $45=9\times 5$, &c., as shown in the multiplication table. The rule is stated thus:—*Multiply the multiplicand by one of the factors of the composite number, and the successive products by the other factors.*

Multiply 7964 by 48. According to the table 48 is 6×8, or 4×12, therefore

$$7964\times 48\begin{cases}\text{is } 7964\times 6=47784\times 8=382272\\ \text{or } 7964\times 4=31856\times 12=382272\end{cases}$$

Similarly, 4785×14 and 382272×36 yield

$$4785\times 7 = 33495\times 2=66990$$
$$382272\times 12=4587264\times 3=13761792$$

This method is not, however, confined to composite numbers, but may be extended to all numbers whatever. For if the factors of a composite number, a little greater or less than the multiplier, are known, then we might proceed in this way:—Multiply by the factors of that composite number which is nearest in value to the multiplier (less or more), and then proceed as before; and next increase or diminish the product found, according as the composite number is less or greater than the multiplier, by the product of their difference into the multiplicand—the result will evidently be the product of the multiplicand by the multiplier.

Suppose it be now required to multiply 7964 by 57.

(1) Since $57=7\times 8+1$.

$$\begin{array}{rr} & 7964\\ & 7\\ \hline & 55748\\ & 8\\ \hline \text{To} & 445984=7964\times 56\\ \text{Add} & 7964=7964\times 1\\ \hline & 453948=7964\times 57\end{array}$$

(2) Since $57=10\times 6-3$.

$$\begin{array}{rr} & 7964\\ & 10\\ \hline & 79640\\ & 6\\ \hline \text{From} & 477840=7964\times 60\\ \text{Take} & 23892=7964\times 3\\ \hline & 453948=7964\times 57\end{array}$$

The method here shown is very convenient when the multiplier is small; but when it is very large, we must, for the sake of further convenience, modify the rule so as to be applicable upon a mere knowledge of the general composition of numbers. Thus, suppose we are required to multiply 7964 by itself; that is, to find 7964×7964.

Since $7964=7000+900+60+4=7\times 1000+9\times 100+6\times 10+4$.

$$\begin{array}{rl} 7964\times 4= & 31856= \quad 4 \text{ times}\\ 10 & \\ \hline 10 \text{ times } 79640\times 6= & 477840= \quad 60 \text{ times}\\ 10 & \\ \hline 100 \text{ times } 796400\times 9= & 7167600= \quad 900 \text{ times}\\ 10 & \\ \hline 1000 \text{ times } 7964000\times 7= & 55748000=7000 \text{ times}\\ \hline \text{The sum of these}= & 63425296=7964 \text{ times.}\end{array}$$

This process, which is applicable to all numbers however great, may be expressed in the following rule:—

Multiply the given number by 10, *the product by* 10, *and so on, as often as there are figures in the multiplier* less one. *Multiply the given number by the units of the multiplier—the first product* (*or* 10 *times the given number*) *by the tens, the second product* (*or* 100 *times the given number*) *by the hundreds, and so on. The sum of these products being the sum of the products of the multiplicand by the units, the tens, the hundreds, &c., of the multiplier, must evidently be the product of the multiplicand by the multiplier.*

This method is important, chiefly from the applications hereafter to be made of it; but we recommend the student to use it as a check on operations by the ordinary method; that is, as a mode of proving the accuracy of his work by trying whether his results agree when obtained by both methods. He will find the constant practice of this method of great use from the additional illustration which the one rule affords of the principles of the other.

The following examples may now be worked by the student.

1.	75649×579	Answer	43800771
2.	687000×356	"	244572000
3.	530674×45007	"	23884044718
4.	9701375×30000	"	291041250000
5.	537084000×5907000	"	3172555188000000
6.	$102030405\times 504030201$	"	51426405540261405
7.	$987654321\times 123456789$	"	121932631112635269

When any number is multiplied by itself any number of times, the result is called a *power* of the number, the degree of which is marked by the number of factors, and according to the language employed we call the number itself the first power.

Thus, 5 is called the	first	power of 5,
5×5	second	power of 5,
$5\times 5\times 5$	third	power of 5,
$5\times 5\times 5\times 5$	fourth	power of 5,

and so on. The second and third powers are usually called the *square* and *cube*, from certain connections with the square and cube in geometry. The following cases will serve as exercises in the multiplication of numbers:—

Number.		Square.		Cube.
125	...	15625	...	1953125
216	...	46656	...	10077696
343	...	117649	...	40353607
512	...	262144	...	134217728
729	...	531441	...	387420489

The fifth power of 36 is 60466176
" fourth " 44 is 3748096
" fourth " 889 is 624607283041

Note that the square of an *odd* number is *odd*, and of an *even* number *even*. Odd numbers added together without leaving out any always yield square numbers—*e.g.* $1+3=4$; $1+3+5=9$; $1+3+5+7=16$—the squares respectively of 2, 3, and 4. Every *fourth* power is a square, and every *sixth* both a square and a cube.

There are many ways of forming questions for exercise in multiplication; but, perhaps, the following is on the whole the best:—Take two numbers and multiply each by itself, and subtract the square of the less from the square of the greater; thus, supposing the numbers taken to be 121 and 235,

$$\begin{array}{r}235\times 235=55225\\ 121\times 121=14641\\ \hline \text{Difference}=40584\end{array}$$

Take now the sum and difference of the numbers chosen, and multiply them together: the result should be the same as before.

$$\begin{array}{rcr} 235 & \qquad & 235\\ 121 & & 121\\ \hline \text{Sum}=356 & & 114=\text{difference.}\end{array}$$

Then $356\times 114=40584$, as before.

In this way any number of exercises may be constructed, all furnishing their own answers.

When the factors are very large, it is often convenient to make a table of the products of the multiplicand by the first nine figures; the work is then performed by simply transferring the numbers in the table to their respective places under the multiplier, and finding their sum as in the ordinary rule.

A table of this kind is easily constructed, and involves little risk of error. It can be made wholly by addition; but advantage may be taken of the facility with which a particular line may be doubled to give another. We shall take an example, and indicate on the side of the table how the successive lines are got.

Suppose we require to multiply 2768954837 by 74829536.

TABLE OF MULTIPLICAND.

1 time = 2768954837	1st
2 times = 5537909674	2nd = 1st × 2
3 times = 8306864511	3rd = 2nd + 1st
4 times = 11075819348	4th = 2nd × 2
5 times = 13844774185	5th = 2nd + 3rd
6 times = 16613729022	6th = 3rd × 2
7 times = 19382683859	7th = 3rd + 4th
8 times = 22151638696	8th = 4th × 2
9 times = 24920593533	9th = 4th + 5th

Now, to find the answer to our question, it is only necessary to transfer the lines of this table which answer to the particular figures of the multiplier to our operation, and (taking care that they occupy their proper places according to their numerical value) find their sum as usual. We leave the work to be done by the student; but he ought to get as the answer 207199605657665632.

The actual labour is, we confess, increased by the foregoing process; but we are often far more than recompensed for the trouble of constructing the table by the certainty which it affords. There is an unpleasant mental exertion involved in such long operations, when the eye has to travel continually from multiplier to multiplicand and product, which are at some distance from each other. This materially increases the risk of error, and renders it almost always essential to do the work twice over, but this indeed ought always to be done, especially where the result is important.

There are a number of practical and easy abbreviations of multiplication which greatly facilitate common calculations. Of these we note the following:—

1. To multiply by 5, annex a cipher to the multiplicand and divide by 2—*e.g.* $73248 \times 5 = 732480 \div 2 = 366240$; similarly 50, 500, 5000, &c., by annexing one cipher more than the multiplier contains.
2. To multiply by 9, which is *one* less than *ten*, annex a cipher to the multiplicand, and from that subtract the multiplicand itself—*e.g.* $84237 \times 9 = 842370 - 84237 = 758133$.
3. To multiply by 11, which is *one* more than *ten*, annex a cipher to the multiplicand, and to that add the multiplicand—*e.g.* $84237 \times 11 = 842370 + 84237 = 926607$.
4. To multiply by 25, add two ciphers and divide by 4; by 125, annex three ciphers and divide by 8—*e.g.* $730842 \times 25 = 73084200 \div 4 = 18271050$; $730842 \times 125 = 730842000 \div 8 = 91355250$.
5. To multiply by any number from 11 to 19 inclusive, multiply by the units figure, and to the number to be carried add the number in the multiplicand which has last been multiplied—*e.g.* 4732×17. First place rightly— and thereupon proceed thus—seven times two are 14, put down 4 and carry 1, to which add 2 making 3; seven times three are 21 and 3 are 24, put down 4 and carry 2, to which add $3 = 5$; seven times seven are 49 and 5 are 54, put down 4 and carry 5, to which add $7 = 12$; seven times four are 28 and 12 are 40, of which put down the cipher and then carry the 4, to which add 4 making 8, and the answer is 80444.

$$\begin{array}{r} 4732 \\ 17 \\ \hline 80444 \end{array}$$

6. In multiplying by numbers one less than any number of tens (*e.g.* 69) it will be found easy to multiply by the next higher number of tens (*e.g.* 70) and subtract the multiplicand—*e.g.*

$$2374 \times 69 = 23740 \times 7 = 166180 - 2374 = 163806 \text{ answer.}$$

The observation of similar possibilities, the working out of accounts in these and in the ordinary forms, and comparing them one with another, will greatly assist the careful student in the manipulation and management of figures.

THE LATIN LANGUAGE.—CHAPTER IV.

PRONOUNS—THEIR NATURE, ACCIDENCE, MEANING, COMPOSITION, CHARACTERISTICS, AND DISTINCTIONS.

THE pronoun is the most peculiar of the class of words employed to indicate notions of existent persons and things. Speech is not only used for narration but for conversation. In narration, the relations of persons and things to each other require to be pointed out; but in conversation —or the oral communication of thought—the relations of personality are specially introduced. In consideration of the frequency with which we would be under the necessity of naming ourselves and others while holding intercourse with them, and the discomfort which such repetition of names would occasion, men have contrived a kind of word to stand as a substitute for, and to be used instead of, such nouns. So far as a speaker is concerned personally, all existences range themselves under three clearly discriminated relations: (1) his own, as speaker; (2) that of those to whom he addresses himself, as hearers, either in reality or in supposition; and (3) the things spoken of or about, as the topics of his discourse. The deputy word or symbolic sign for one's self is *ego*, I; for one's hearer, *tu*, thou. As the persons related to each other as speaker and hearer are always, really or supposedly, in one another's presence, no indication of gender is included in these words, though they vary to denote number and case. Persons or things spoken about being in the majority of cases absent, require to have their gender indicated as well as their number and case. We do this in English by the words *he*, *she*, and *it*. There are, however, in Latin no special pronouns appropriated to the indication of the third person, though in a manner *is*, *ille*, *hic*, &c., are used for that purpose. As a rule, the personal pronouns are not expressed in Latin unless it is desirable for some reason to express a contrast or to emphasize the relation of personality. The ending of the Latin verb plainly shows which person is referred to without the aid of a pronoun; as the word *amo*, by the ending *o*, indicates that the verb is of the first person singular without our adding the pronoun *ego*. There is a defective pronoun—*sui*—which, under certain circumstances, the Romans did employ to prevent the need for repeating the nouns when it was desirable to avoid doing so. It is sometimes called the reflexive pronoun, because it refers for its pronominal signification to the subject of the sentence. It is used when the subject requires to be mentioned again in the same sentence; that is, it refers to the subject in a subordinate relation. On this account it is never the subject of a sentence; therefore it has no nominative, and so is defective. Instead of saying, for instance, *Caius Caium occidit*, Caius killed Caius, we say *Caius se occidit*, Caius killed himself; and *Animalia inter animalia pugnant*, Animals among animals fight, becomes *Animalia inter se pugnant*. In this way, *sui* is used as a third personal pronoun, and as it always refers to some person or thing already known, the number and gender of which are therefore also already known to the speaker and indicated to the hearer, it has no variation in declension except for case. It is because *ego*, *tu*, and *sui* are always used instead of a noun that they are specially called substantive pronouns; while those which can be used not only instead of but also along with nouns or other pronouns, and are therefore declinable in all cases, genders, and numbers like adjectives, are called adjective pronouns.

As the knowledge of the pronouns in all their forms is peculiarly necessary to the ready comprehension of the relations of the words whose place they supply or to which they refer, we shall present to the learner a more detailed and extended exhibition of pronominal forms than is usual in ordinary grammars, and shall subjoin a few annotations regarding their uses and powers which may be regulative and instructive, and to which reference may be made in the course of subsequent study. In the meantime we shall put the matter thus to be given in due grammatical form; and commend the careful and diligent preparation of the whole of the following paradigms, till they have quite settled down into the memory as words written indelibly there. The explanatory remarks which follow will, in some measure, indicate the importance of attending to this advice, and will be of service afterwards

in the translation and composition of Latin. Wherever it seemed needful the quantity has been noted.

PRONOUN.

A pronoun (from *pro*, for, and *nomen*, a name) is a word which supplies the place of a noun.

Pronouns are divided into five classes:—

(1) Substantives or Personals, which represent nouns— *ego*, *tu*, *sui*.

(2) Demonstratives, which point out a person or thing present—*ille*, *ipse*, *iste*, *hic*, *is*.

(3) Relatives, which refer to something mentioned before— *quis*, *qui*.

(4) Possessives, which denote possession—*meus*, *tuus*, *suus*, *noster*, *vester*.

(5) Gentiles or Patrials, which signify one's country— *nostras*, *vestras*, *cujas*.

Quis and *cujas* are also used as and called interrogatives.

Pronouns take the case which the nouns they represent would have if they were repeated, and when requisite indicate their proper gender.

(1) The Pronouns Substantive have the same number and cases as nouns, but they differ from them in having no indication of gender. They are called pronouns of the first, second, and third persons, and are thus declined—

FIRST PERSON.				SECOND PERSON.				THIRD PERSON.	
Singular.		*Plural.*		*Singular.*		*Plural.*		*Singular* and *Plural.*	
N. Ego,	*I.*	Nōs,	*we.*	*N.* Tu,	*thou* or *you.*	Vōs,	*ye* or *you.*	*G.* Sui,	*of himself, herself, itself,* or *themselves.*
G. Mei,	*of me.*	Nostrûm or nostrî,	*of us.*	*G.* Tui,	*of thee.*	Vestrûm or vestrî,	*of you.*		
D. Mihi,	*to me.*	Nobis,	*to us.*	*D.* Tibi,	*to thee.*	Vobis,	*to you.*	*D.* Sibi,	*to himself,* &c.
Ac. Me,	*me.*	Nos,	*us.*	*Ac.* Te,	*thee* or *you.*	Vos,	*you.*	*Ac.* Se or sēsē,	*himself,* &c.
Ab. Me,	*by me.*	Nobis,	*by us.*	*Ab.* Te,	*by thee.*	Vobis,	*by you.*	*Ab.* Se or sēsē,	*by himself,* &c.

In Latin, the second person singular (not plural, as in English) is used in addressing a single person; as *Te audio*, I hear you.

These forms are emphasized by the addition of *mĕt*, *tĕ*, and *ipse*, as *egomet*, *tutĕ*, *tutĕmet*, *temetipsum*, *sibimetipsi*, &c., and the accusatives *mē*, *tē*, *sē* admit of the reduplicated forms *meme*, *tete*, *sese*.

The preposition *cum* is added to the ablative of these pronouns when used along with them; as *mecum*, with me; *tecum*, with thee; *nobiscum*, with us, &c. It may be as well here to observe how the pronunciation of *nobis* is changed when *cum* is added to it. All Latin words of two syllables are accented on the first; as *pu'-er*, *gra'-tus*, *no'-bis*, &c. In words of more than two syllables, if the last but one be long, the accent will fall on it; if short, on the last but two; as *il-lī'-us*, *cīv-ĭ'-lis*, *ĕl-ĕ-mēn'-tŭm*, &c., but *splēn'-dĭd-ŭs*, *am-ā'-bĭl-ĭs*, &c. In this way the accent therefore of *nobiscum* falls on the second syllable, *nō-bīs'-cum*. A similar change of accent takes place when *que*, and, is joined to such words; as *pa'-ter*, *pa-ter'-que*, *mar'-i*, *mar-ĭ'-que*, &c.

The English pronouns *he*, *she*, *it*, &c., are expressed in Latin by means of the adjective pronouns.

Ego and *tu* have, properly speaking, no genitive or other oblique cases. They really make use, for these cases, of the possessive pronouns *meus*, *tuus*, *noster*, and *vester*, according to a usage common to most languages, that a possessive may take the place of the genitive of a person. We not only can say *mea scripta*, my writings, but we may say, with Horace, *Mea scripta recitare timentes*, The writings of me fearing to recite (1 Serm. iv. 23). In the genitive plural *nostrî* and *vestrî* are used only of the persons as a whole, *i.e.* as a single object of thought; as *memoria nostrî tua*, your remembrance of us; *nostrûm* and *vestrûm* (which were anciently used in the full form, *nostrorum* and *vestrorum*) when we speak of the persons as a collection of separate or separable persons, as Cicero says, *Patria est communis omnium nostrûm parens*, Our native country is the common parent of us all (Cat. i. 7). Zumpt states the distinction thus: "*Nostrûm* and *vestrûm* refer to the noun, the subject of discourse; *nostrî* and *vestrî* to the object."

(2) The Demonstrative Pronouns are *is*, *hic*, *ille*, *ipse*, *iste*.

Is, *that* (or *he*, *she*, *it*), simple or unemphatic.

	Singular.				*Plural.*		
	M.	F.	N.		M.	F.	N.
N.	Is	ĕă	ĭd	*N.*	Iī	ĕæ	ĕă
G.	Ejŭs	ējŭs	ējŭs	*G.*	Eōrum	ĕārum	ĕōrum
D.	Eī	ĕī	ĕī	*D.*	Iīs *or* ĕīs (*m. f. n.*)		
Ac.	Eum	ĕam	ĭd	*Ac.*	Eōs	ĕās	ĕă
Ab.	Eō	ĕā	ĕō	*Ab.*	Iīs *or* ĕīs (*m. f. n.*)		

Is, *ea*, *id* is a simple demonstrative, pointing out a person already referred to or one just about to be spoken of in a relative clause.

The pronouns *is* and *hic* often, in a principal clause, represent the relative of a subordinate clause.

Idem, *eadem*, *idem*, the same (compounded of *is* and *dem*), is thus declined:—

	Singular.				*Plural.*		
	M.	F.	N.		M.	F.	N.
N.	Idem	eadem	idem	*N.*	Iidem	eædem	eadem
G.	Ejusdem	*for all genders*		*G.*	Eorundem (*m. n.*)	earundem	
D.	Eidem			*D.*	Iisdem *or* eisdem (*m. f. n.*)		
Ac.	Eundem	eandem	idem	*Ac.*	Eosdem	easdem	eadem
Ab.	Eodem	eadem	eodem	*Ab.*	Iisdem *or* eisdem (*m. f. n.*)		

Hīc, *this* (*person* or *thing near me*), emphatic.

	Singular.				*Plural.*		
N.	Hīc	hæc	hōc	*N.*	Hī	hæ	hæc
G.	Hūjŭs	hūjŭs	hūjŭs	*G.*	Hōrum	hārum	hōrum
D.	Huīc	huīc	huīc	*D.*	Hīs	hīs	hīs
Ac.	Hunc	hanc	hōc	*Ac.*	Hōs	hās	hæc
Ab.	Hōc	hāc	hōc	*Ab.*	Hīs	hīs	hīs

(In *huic u* is not sounded; formerly it rhymed with pike, now with peak.)

Illĕ, *that* (*person* or *thing yonder*).

	Singular.				*Plural.*		
N.	Illĕ	illă	illŭd	*N.*	Illī	illæ	illă
G.	Illīŭs	illīŭs	illīŭs	*G.*	Illōrum	illārum	illōrum
D.	Illī	illī	illī	*D.*	Illīs	illīs	illīs
Ac.	Illum	illam	illŭd	*Ac.*	Illōs	illās	illă
Ab.	Illō	illā	illō	*Ab.*	Illīs	illīs	illīs

Ipse, ipsa, ipsum, *self*, *himself*, *herself*, *itself*, when used by itself, is a personal pronoun of the third person.

	Singular.				*Plural.*		
N.	Ipse	ipsa	ipsum	*N.*	Ipsi	ipsæ	ipsa
G.	Ipsius	*for all genders*		*G.*	Ipsorum	ipsarum	ipsorum
D.	Ipsi			*D.*	Ipsis (*for all genders*)		
Ac.	Ipsum	ipsam	ipsum	*Ac.*	Ipsos	ipsas	ipsa
Ab.	Ipso	ipsa	ipso	*Ab.*	Ipsis (*for all genders*)		

Ipse may be used to refer to any of the three persons. Its general office is to distinguish with emphasis and indicate specific individuals with precision. In its use with reference to the third person, *sui* relates to the principal subject, *ipse* to any subordinate one which requires to be distinctly noticed and marked out; as *Testamentum ipsius manu scriptum imperator ostendit*, *Testamentum suo manu scriptum imperator ostendit*, may each be translated by the words, The emperor showed him a will written with his own hand; but the hand in the first case is that of the person to whom the will was shown, in the latter it is that of the emperor himself.

Hic, *iste*, *ille* are sometimes called indicative pronouns, for they indicate, as *objects* referred to, the persons spoken of as subjects to a verb; *e.g.* *hic*, this (person or thing here); *iste*, that (person or thing near the person addressed); *ille*, that (distant person or object, sometimes a person so remarkable as to attract attention in spite of distance, and therefore very distinguished). This *ille* of eminence generally, though not always, follows its noun, if there is not an adjective with it; as *Antipater ille Sidonius*.

Iste, ista, istud, *that* (*near you, that of yours*).

	Singular. M.	F.	N.	*Plural.* M.	F.	N.
N.	Iste	ista	istud	Isti	istæ	ista
G.	Istius	*for all genders.*		Istorum	istarum	istorum
D.	Isti			Istis (*for all genders*)		
Ac.	Istum	istam	istud	Istos	istas	ista
Ab.	Isto	ista	isto	Istis (*for all genders*)		

(3) Relative Pronouns, which bring two sentences into one.

Qui, quæ, quod, *who, which, that.*

	Singular.			*Plural.*		
N.	Qui	quæ	quod	Qui	quæ	quæ
G.	Cujus	cujus	cujus	Quorum	quarum	quorum
D.	Cui	cui	cui	Queis *or* quibus (*m. f. n.*)		
Ac.	Quem	quam	quod	Quos	quas	quæ
Ab.	Quo	qua	quo	Queis *or* quibus (*m. f. n.*)		

The relative *qui* has also *quî* in the ablative in all genders and in both numbers. *Qui* is sometimes used interrogatively for *quis.*

Quis, quæ, quod *or* quid, *who, which, what,* interrogatively.

	Singular.			*Plural.*		
N.	Quis	quæ	quid *or* quod	Qui	quæ	quæ
G.	Cujus	cujus	cujus	Quorum	quarum	quorum
D.	Cui	cui	cui	Queis *or* quibus (*m. f. n.*)		
Ac.	Quem	quam	quid *or* quod	Quos	quas	quæ
Ab.	Quo	qua	quo	Queis *or* quibus (*m. f. n.*)		

The relative is never governed in case by any word which is not in its own clause.

Id quod or *quæ res* is often used as a relative reference to a sentence forming its antecedent.

The relatives are used as interrogatives before nouns; as *Qui gurges?* What whirlpool? *Quod mare?* What sea? *Qualis homo?* What sort of a man? *Quantus fluctus?* How great a wave? *Quot homines?* How many men?

Almost always before nouns, when we speak of persons or objects generally, and consequently when the noun can be without ambiguity omitted, *quis* and *quid* are used instead of *qui* and *quod;* as *Quis venit?* Who comes? *Quid quæris?* What seek ye?

Of the two terminations in the neuter, the first, *quid,* is a pronoun, and never has a noun with it; as *Quid dicis?* What do you say? the other, *quod,* is an adjective, and always has a noun with it; as *Quod templum?* What temple?

The neuter *quid* is used only in the nominative and accusative; as *Quid est?* What is it? The other cases are made up by the noun *res,* thing; as genitive, *cujus rei?* of what? dative, *cui rei?* to what? ablative, *qua re?* from what?

The compounds of *qui, quis* follow the declension of those pronouns. *Qui* is always placed first in etymological composition; *quis* may be first, middle, or last. Observe that *ecquis* and *aliquis* make the feminine gender of the nominative case singular, and the neuter of the nominative and accusative cases plural, in *quă.*

Aliquis, *some.*

	Singular.			*Plural.*		
N.	Alĭquis	alĭqua	alĭquid *or* alĭquod	Alĭqui	alĭquæ	alĭqua
G.	Alicujus	*for all genders*		Aliquōrum (*m. n.*) aliquārum		
D.	Alicui			Aliquĭbus. aliqueis, *or* aliquīs.		
Ac.	Aliquem	aliquam	aliquid *or* aliquod	Aliquos	aliquas	aliqua
Ab.	Aliquo	aliqua	aliquo	Aliquĭbus, aliqueis, *or* aliquīs.		

(4) The Possessive Pronouns (or pronominal adjectives) are declined like adjectives. Therefore decline

as Bŏnŭs,

*Mĕŭs,	mĕă,	mĕum,	*my, mine.*
*Tŭŭs,	tŭă,	tŭum	*thy, thine.*
*Sŭŭs,	sŭă,	sŭum,	*his, her, its, their own.*
Cūjŭs,	cūjă,	cūjum,	*whose; whose?*

Mĕŭs has vocative masculine mī. Tŭŭs, sŭŭs have no vocative.

as Nĭgĕr,

*Nostĕr,	nostră,	nostrum,	*our.*
*Vestĕr,	vestră,	vestrum,	*your.*

* With these five adjective pronouns the substantive is generally expressed.

as Felix,

Cūjas,	cujatis,	*of what country?*
Nostras,	nostratis,	*of one's own country, native.*
Vestras,	vestratis,	*of your country.*

The following table comprises nearly the whole of the adjective pronouns, arranged in related classes, with their most general significations carefully discriminated:—

Masculine.	*Feminine.*	*Neuter.*	
Hic,	hæc,	hoc,	*this (person or thing present or near the speaker).*
Ille,	illa,	illud,	*that (person or thing yonder at a distance).*
Iste,	ista,	istud,	*that (person or thing near the person addressed).*
Ipse,	ipsa,	ipsum,	*the very, the self-same.*
Is,	ea,	id,	*this or that or the same.*
Idem,	eadem,	idem,	*the very same as.*
Qui,	quæ,	quod,	*which, what (relative), referring to kind, condition, or quality.*
Quidam,	quædam,	quoddam,	*a certain one (or more) known; some (not all).*
Quivis,	quævis,	quodvis,	*any you choose (of supposed persons).*
Quilibet,	quælibet,	quodlibet,	*any you please.*
Quicunque,	quæcunque,	quodcunque,	*whatsoever.*
Quis,	quæ,	quid,	*what (interrogative or indefinite), referring to a name required.*
Aliquis,	aliqua,	aliquid,	*some one; some (at all events, even if not many or much).*
Ecquis,	ecqua,	ecquid,	*who? what? whether any, any one?*
Quisque,	quæque,	quodque,	*each, every (of real persons).*
Quantusquisque,	quantusquæque,	quantusquodque,	*how few?*
Quisnam,	quænam,	quidnam,	*what then?*
Quisquis,	quisquis,	quidquid,	*whatsoever (of many).*
Quispiam,	quæpiam,	quodpiam,	*any one soever; some one or other*
Quisquam,	quæquam,	quidquam,	*any one (of many).*
Unus,	una,	unum,	*one (of many).*
Unusquisque,	unusquæque,	unusquodque, or unusquidque,	*each one.*
Solus,	sola,	solum,	*only, sole.*
Totus,	tota,	totum,	*the whole, entire.*
Ambo,	ambæ,	ambo,	*both (halves) taken together.*
Ullus,	ulla,	ullum,	*any (of many).*
Nullus,	nulla,	nullum,	*no one, no (none of many).*
Alius,	alia,	aliud,	*another (of many).*
Alter,	altera,	alterum,	*the other one (of two).*
Uter,	utra,	utrum,	*either, whichever of (the two).*
Neuter,	neutra,	neutrum,	*neither (of two).*
Uterque,	utraque,	utrumque,	*each (of two); both the one and the other.*
Utercunque,	utracunque.	utrumcunque,	*whichsoever (of two).*
Alteruter,	alterutra,	alterutrum,	*the one or the other.*
Utervis,	utravis,	utrumvis,	*either one (of any two) you prefer.*
Uterlibet,	utralibet,	utrumlibet,	*whichsoever (of any two) you please.*

Meus, tuus, suus, noster, and *vester* are used when action or possession is signified; as *meus pater*, my father; *Favet desidero tuo*, He favours thy desire; but they are used in the genitive case when a person is signified; as *Languet desiderio tui*, She languishes for want of you. They also take after them such genitives as *ipsius, solius, unius, duorum, trium, omnium, plurium, paucorum, cujusque*, as well as the genitive cases of participles; as *Dixi mea unius opera rempublicam esse salvam*, I said that by my single service the republic was safe (Cicero).

Is, ea, id; talis, is, e; tantus, a, um, and *tot* are respectively the demonstrative or antecedent pronouns to *qui, quæ, quod; qualis, is, e; quantus, a, um*, and *quot*.

Qui means which? (exactly); *qualis*, which (in point of quality), of which sort? *quantus*, which (in point of magnitude), of which size, how great? *quot*, which (in point of number), how many? Their relatives, *idem, talis, tantus*, and *tot*, mean, respectively, such (exactly); such (in quality); such (in size); such (in number). *Talis . . . qualis; tantus . . . quantus* are often translated into English by "such . . . as;" and therefore we require to note particularly whether *such* signifies of such a sort (quality), of such a size (magnitude).

Ambo is used of two conjointly when the things referred to are naturally a pair, or are so conjoined that what is said of them is not true of each singly, but only of both taken together. *Uterque* is used of each of two individually, with regard to things which are not naturally conjoined as a pair, but may be spoken of in any particular relation as a pair.

Döderlein says *ambo* regards the two as halves, *uterque* as wholes; hence *ambo* always takes a verb in the plural, *uterque* either a singular or a plural one.

The following are indeclinable:—*tot*, so many; *totidem*, just so many; *quot*, as many; *aliquot*, some; *quotquot*, however many.

Some of the foregoing pronouns adjective are better (because more briefly) translated by such English pronouns as will convey the same sense with sufficient clearness; thus he, she, it, him, her, they, and them are frequently the best equivalents of any one of the demonstrative pronouns, as they are sometimes called, *hic, ille, iste, ipse*, or *is*, in their respective genders, numbers, and cases. *Qui*, which is called the pronoun relative, may, in the same way, generally be translated in the masculine and feminine gender by who or whom, according to the case; *quicunque* and *quisquis* by whosoever, &c.; and *quis*, the interrogative, with its compounds, by whom?

EXERCISE.

The following examples, drawn from various sources, will provide ample illustrations of the use, signification, and form of these pronouns. In studying them we would strongly advise the student, that (1) by careful search in the foregoing declension-tables, he should fix upon and ascertain the precise forms in them which resemble the pronouns in these examples; (2) by looking at the noun accompanying it, decide upon the number, gender, and case of each pronoun employed, and fix that and the reasons which lead to the decision firmly in the memory; and (3) by referring to the translation given and the remarks made above on the special uses and implications of the several pronouns, see what particular remark has application to each sentence as he proceeds to investigate it:—

Hic homo,	*this man.*
Hæc fœmina,	*this woman.*
Hoc regnum,	*this kingdom.*
Hic dies,	*this day.*
Vir qui,	*the man who.*
Fœmina quæ,	*the woman who.*
Negotia quæ,	*a business which.*
Ego qui,	*I who.*
Nos qui,	*we who.*
Tu qui,	*thou who.*
Vir quem,	*the man whom.*
Viri quos,	*the men whom.*
Mulier quam,	*the woman whom.*
Mulieres quas,	*the women whom.*
Cujus victoriæ	*of whose victory.*
Hoc tumultu,	*in this brawl.*
Quo casu?	*by what accident?*
Eas regiones,	*these regions.*
Negotium quod,	*an affair which.*
Huic Miltiadi,	*to this Miltiades.*
Exortus hujus diei,	*the dawn of this day.*
Ipsum hoc membrum	*his very limb itself.*
Hoc responso oraculi,	*on this reply of the oracle.*
Incolas ejus insulæ,	*the inhabitants of this island.*
Voluntate eorum,	*of their own will.*
Nostrates philosophi,	*the philosophers of our own country.*
Nostratia verba,	*the words of our own country.*
Ipsarum urbium,	*of these very cities.*
Cujus ratio,	*the reason of which.*
Mulieres quarum,	*the women of whom.*
Locum quendam,	*which (particular) place.*
Adventu horum,	*by the arrival of these.*
Anime mi,	*O my soul.*
Cujus canis hic est?	*whose dog is this?*
Quibuscum ambulas?	*with whom art thou walking?*
Quis hunc altum murum ædificat?	*who is building this high wall?*
Quid amabilius virtute?	*what is more lovely than virtue?*
Alter oculorum,	*one of the (two) eyes.*
Unus digitorum,	*one of the (ten) fingers.*
Ipse ego *or* ipse egomet,	*I myself.*
Tute ipse,	*thou thyself.*
Rex ipse,	*the king himself.*
Virtus ipsa,	*virtue itself,* or *herself.*
Ipsum periculum,	*danger itself.*
Ipse dixit,	*he himself speaks.*
Quod nomen,	*which name.*
Qui casus,	*which (kind of) chance.*
Quis casus?	*what chance (at all)?*
Quid tibi nomen est?	*what is thy name?*
Quis fuit igitur?	*who was it then?*
Cui quam civi,	*to any citizen.*
Quis homo est?	*who is this man?*
Aliquod monstrum,	*some monster.*
Aliquid monstri,	*something of a monster.*
Magnus ille Alexander,	*that great Alexander.*
Ego videor mihi,	*I seem to myself.*
Amo me,	*I love myself.*
Hi sui juris sunt,	*these are his rights.*
Libris me delecto,	*I delight myself with books.*
Cæsar me invitat,	*Cæsar invites me.*
Justitia propter sese colenda est,	*justice is to be practised for her own self's sake.*
Trahit sua quemque voluptas,	*his own (special) pleasure attracts each one.*
Triginta dies erant ipsi,	*thirty days there were themselves (= complete).*
Hi non sunt multi,	*these are not many.*
Virtus est per se ipsa laudabilis,	*virtue is praiseworthy for her own very self.*
Quod quique obliget id quisque teneat,	*that which belongs to everyone everyone may hold.*
Ecquis me ho-die vivit fortunatior!	*who lives to-day more fortunate than I!*
Non semper idem floribus est color,	*flowers have not always the same colour.*
Nicias tua sui memoria delectatur,	*Nicias is immensely delighted with thy remembrance of him.*
Ego ipse cum Platone, non invitus, erro,	*I myself err, not unwillingly, along with Plato.*
Ipse se quisque diligit,	*everyone loves himself.*
Miltiades ipse pro se dicere non potuit,	*even Miltiades could not speak for himself.*
Nos debemur morti,	*we are due to death.*
Solon qui scripsit,	*Solon who wrote.*
Arbor quæ floret,	*the tree which flourishes.*
Cœlum quod omnia tegit,	*heaven which covers everything.*
Quod honestum id utile est,	*that which is honest is useful.*
Oderunt eum quem metuunt,	*they hate him whom they fear.*
Arces quas condidit,	*the towers which he built.*
Sceptrum quod gesserat olim,	*the sceptre which he once bore.*

Pronouns enter into composition one with another and with other words in several ways; among others (1) by reduplication, as *meme, tete, sese, quisquis*; (2) by combination, as *hicce* (*hic, hic*), *illic* (*ille* and *hic*), *istic* (*iste* and *hic*), *alteruter, unusquisque*, &c.; (3) by prefixes, as *aliquis* (from *alius*), *equidem* (*ego, quidem*), *ecquis*, (*en* or *ecce*, behold), *neuter*

(*ne* and *uter*), *nullus* (*ne*, *ullus*), &c.; (4) by affixes, of which the following is a list with examples:—

Dem, *met*, *pse*, *pte*, *te* are added to pronouns to give them the added force of "self" and "own" in English; as—

Dem to *is*, as *idem* from *isdem;* so to numerals and adverbs, as *totidem*, *item* (for *itadem*); *tantumdem*, *tandem* (for *tamdem*).

Met to the personal pronouns *ego*, *tu*, *sui* (especially before *ipse*), and to their possessives in all cases (except the genitive plural), as *egomet*, *temet*, *semet;* for *tumet tute* is used.

Nam to *quis*, *qui*, *ecquis*, and *numquis*, to make them more strongly interrogative.

Pse to pronouns of the third person, as *ipse* for *ispsê*.

Pte to the possessives *meus*, *tuus*, *suus* in the ablative case, as *meâpte*, *suâpte*.

Te to pronouns of the second and third person, as *tutĕ*, *iste*.

Dam is demonstrative, as in *quidam*, a certain one; *quondam* (*quomdam*), at a certain time.

Idem to *tot*, as *totidem;* to *tantum*, as *tantumdem*.

Piam and *quam* are added to *quis; piam* affirmatively, as *quispiam; quam* negatively, as *quisquam*.

Que (in the sense of every); *quisque*, every one, *ubique*, every where, *cumque*, every when, *undique*, every whence.

Cunque, at each time (*cumque*) to *qui;* as *quicunque*, whosoever; so *qualiscunque*, of what sort soever, *quotcunque*, how many soever, *utcunque*, when or howsoever, *ubicunque*, wheresoever, *quandocunque*, whensoever, *undecunque*, whencesoever, *quocunque*, whithersoever.

PHYSIOLOGY.—CHAPTER IV.

THE MUSCLES AND MUSCULAR ACTION (*continued*).

The head is a practical illustration of a lever of the simplest sort, *i.e.* one in which the fulcrum is placed between the two opposing forces of weight and power. [See Natural Philosophy, p. 212.] The skull is balanced on the double pivot (which, however, is practically one) supplied by the two upper cervical vertebræ—the atlas and the axis; and the muscles which concur (1) in steadying the head, (2) in moving it sideways, (3) in raising and lowering it, and (4) in governing its rotatory movements, are, in their respective antagonistic action, alternately weight and power. These are the muscles on the explanation of which we are now engaged.

There are three muscles on the throat which pull it downward: (1) the *sterno-hyoideus*, a broad, flat, ribbon-like muscle, passing from the sternum (or breast-bone) to the os-hyoides (or bone of the tongue). (See Plate VII., figs. 4 and 5, *a a*); it pulls the throat directly downward. (2) The *sterno-thyroideus* (*d*, fig. 4), a flat, smooth, ribbon-like muscle, thicker and fleshier than the former, and very uniform in bulk; it passes from the sternum to the thyroid cartilage, and pulls the throat downward. (3) The *omo-hyoideus* (*b*, fig. 4), a long, slender muscle, reaching from each shoulder to the os-hyoides. If either muscle acts singly, it pulls the throat to one side; if both act, one on each side, their power is equally balanced, and they assist the two former in pulling the throat directly downward, and at the same time press the windpipe a little downward and backward. These three muscles are almost continually in action, and are only completely relaxed when we are eating. It is their relaxation which permits of deglutition.

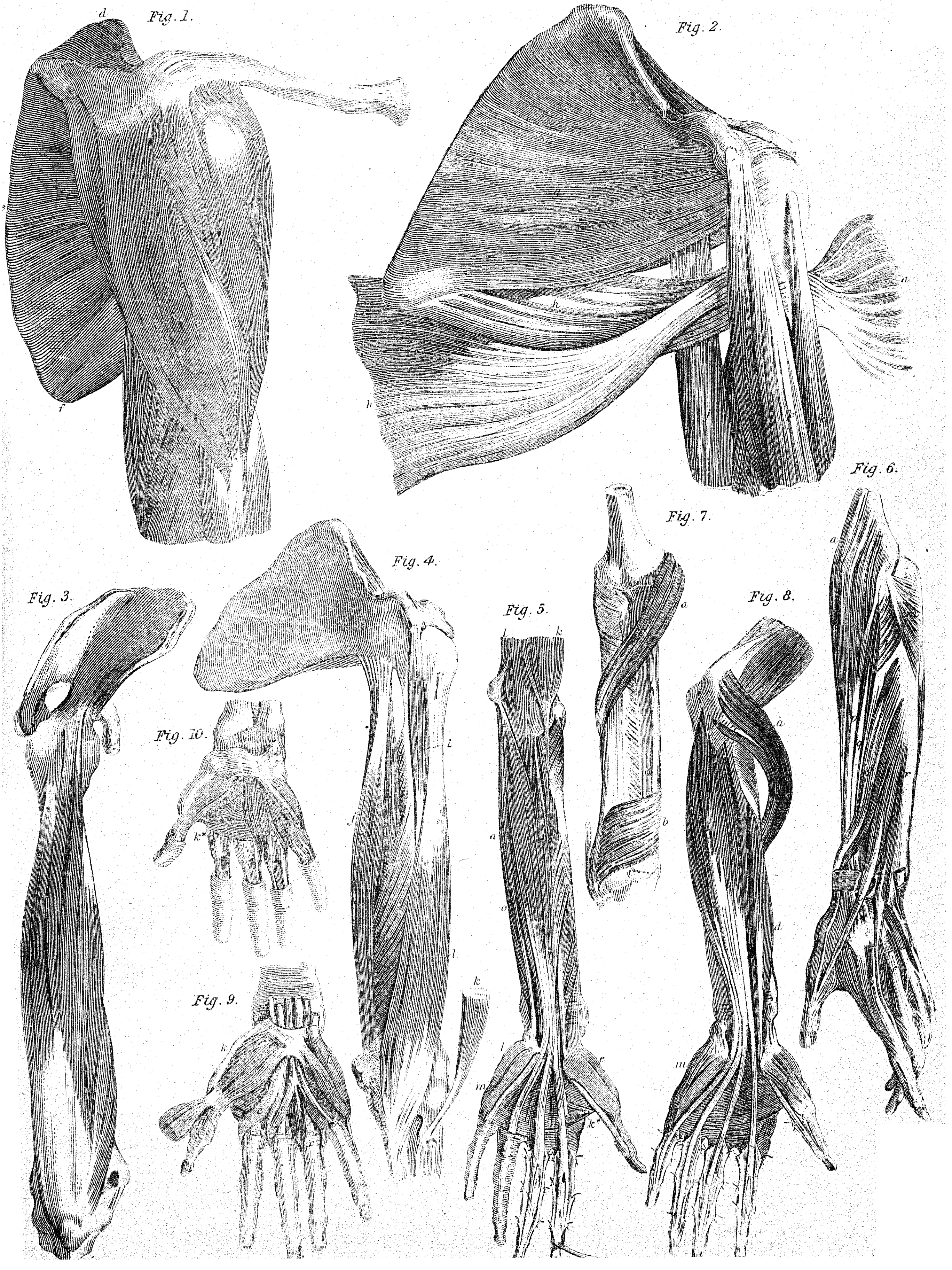
Four muscles on the neck pull the throat upward:—(1) The *mylo-hyoideus* (*g*, figs. 4 and 9), a flat, broad muscle (arising from the whole semicircle of the lower jaw), divided by a tendinous white substance down its middle, in a line with the chin, and inserted at the base of the os-hyoides at the root of the tongue. Some anatomists reckon this muscle, thus divided, as two distinct muscles. (2) *Genio-hyoideus* (*h*, fig. 4), a neat pair of muscles, beautiful and radiated, originating from a small tubercle behind the chin, implanted into the basis of the os-hyoides. The sub-maxillary gland lies between this muscle and the omo-hyoideus, and, in the middle, the duct of the gland pierces the membrane of the mouth, to open beneath the root of the tongue. The mylo-hyoideus and genio-hyoideus move the bone of the tongue forward and upward when the lower jaw is fixed; but when the os-hyoides is fixed by the muscles that come from the sternum or breast-bone, they pull the jaw downward. (3) The *stylo-hyoideus* (*i*, fig. 7) is one of three beautiful slender muscles which, rising about the middle of the styloid process, is fixed into the side of the os-hyoides. Its fibres split above its insertion and form a neat small loop for the passage of the tendon of the digastric muscle. One of the other two styloid muscles is inserted into the pharynx, and the other into the tongue; their common action is to draw back the tongue and pull up the throat. (4) The *digastricus* (*ff*, fig. 4) is a double-bellied muscle; the one, taking its rise from the root of the mastoid process, proceeds obliquely forward and downward, passes by the side of the os-hyoides, slips through the loop of the stylo-hyoideus, and is fixed by a tendinous bridle to the side of the os-hyoides; and then, turning upward towards the chin, ends in a second fleshy node, which is inserted into the lower jaw on the inside of its circle. This muscle, along with the stylo-hyoideus, pulls the throat upward and backward.

There are seven muscles of the throat that move the parts and the cartilages of the larynx or windpipe upon each other:—(1) The *hyo-thyroideus* goes from the thyroid or shield-like cartilage—which lies in front of the larynx, and constitutes that prominent bulge (in men) called *pomum Adami* (Adam's apple)—to the os-hyoides, and compresses and shortens the windpipe. (2) The *crico-thyroideus* (*e*, fig. 6) passes from the upper edge of the cricoid (*ring-like*) to the lower margin of the thyroid cartilage, and is also a compresser and shortener. (3) *Arytenoideus transversus* arises from almost the whole length of one of the arytenoid (*pitcher-like*) cartilages, and is inserted to the same extent into the other. It contracts the glottis by drawing these cartilages towards each other. (4) *Arytenoideus obliquus* (*d*, figs. 10 and 11) rises from the root of one arytenoid cartilage, goes obliquely into the other, draws them together, and closes the *glottis*. (5) *Crico-arytenoideus posticus* (*a*, fig. 10), a small pyramidal muscle arising from the back part of the cricoid, is inserted into the posterior portion of the thyroid cartilage. It rolls the arytenoid cartilages directly outward, lengthens the slit of the glottis, and widening it, produces some of the most delicate modulations of the voice. (6) *Crico-arytenoideus lateralis* (*b*, fig. 11) comes from the sides of the cricoid, and is implanted into the arytenoid cartilage. It rolls them inwards and closes the lips of the rim of the glottis. (7) The *thyro-arytenoideus* (*c*, fig. 11), rising from the posterior surface of the wing of the thyroid, is implanted into the anterior part of the arytenoid cartilages. It pulls them forward and sideways, slackens the ligaments, and thus renders the tone of the voice lower.

The following muscles belong to the palate and pharynx:—(1) *Azygos uvulæ* (*q*, fig. 8), in the centre of the velum pendulum palati, or that curtain which hangs at the back of the throat. There is a small depending pap or point of flesh called the pap of the throat. The azygos uvulæ is the only muscle belonging to this pap, and pulls it upward to keep it out of the way of the morsel about to be swallowed after mastication. (2) *Levator palati mollis* (*p*, fig. 8), rising from the os-petrosum, the Eustachian tube, and sphenoid bone, spreads over the curtain of the throat. It pulls up the curtain when food is to be swallowed, and prevents the food from passing up to the nostrils by extending the velum or curtain backward, protecting the passage. It also covers the mouth of the Eustachian tube or internal opening of the ear, and prevents the food from passing into it, that hearing may be unimpaired. (3) *Tensor palati* (*o*, fig. 8) proceeds from the sphenoid bone and the beginning of the Eustachian tube at the back part of the mouth; it runs along that tube, and, becoming tendinous, turns under the hook of the internal pterygoid process, and mounts again to the side of the curtain of the palate; its office is to pull down the palate, and by stretching it to make it tense. (4) *Constrictor isthmi faucium* begins from the root of the tongue on each side, extends to the middle of the curtain, and terminates near the uvula. The semicircle which this expansion describes forms the first arch that presents itself to the eye when we look into the mouth. This muscle pulls down the curtain and elevates the root of the tongue to meet the veil. (5) *Palato-pharyngeus*, forming the second arch of the throat, begins at the middle of the soft palate, extends round the entry into the fauces, and terminates in the wing or edge of the thyroid cartilage. The first arch belongs to the root of the tongue; the second to the gullet. This muscle contracts the arch of

PHYSIOLOGY.

MUSCLES OF THE UPPER LIMBS.



REFERENCE TO PLATE VIII.

Fig. 1. (c) *Deltoides*
" (d) *Supra spinatus*
" (e) *Infra spinatus*
" (f) *Teres major*

Fig. 2 (a) *Pectoralis major*
" (b) *Latissimus dorsi*
" (g) *Subscapularis*
" (h) *Teres minor*
" (i) *Coraco-brachialis; also fig. 4*
" (k) *Biceps flexor cubiti; also figs. 4 and 5*

Fig. 3. (j) *Triceps extensor cubiti; also fig. 4*

Fig. 4. (i) *Coraco-brachialis; also fig. 2*
" (j) *Triceps extensor cubiti; also fig. 3*
" (k) *Biceps flexor cubiti; also figs. 2 and 5*
" (l) *Brachialis anticus; also fig. 5*

Fig. 5. (a) *Flexor digitorum sublimis perforatus*
" (e) *Flexor brevis pollicis*
" (k) *Biceps flexor cubiti; also figs. 2 and 4*
" (k*) *Adductor pollicis; also fig. 10*
" (l) *Brachialis anticus; also fig. 4*

Fig. 5. (n) *Flexor carpi radialis*
" (o) " " *ulnaris*

Fig. 6. (a) *Supinator radii longus*
" (b) " " *brevis*
" (f) *Extensor digitorum communis*
" (g) " *ossis metacarpi pollicis*
" (h) *Primi internodii pollicis*
" (i) *Secundi* " "
" (m) *Anconeus*
" (p) *Extensor carpi radialis longior*
" (q) " " " *brevior*
" (r) " " *ulnaris*

Fig. 7. (a) *Pronator radii teres*
" (b) " " *quadratus*

Fig. 8. (b) *Flexor digitorum profundus perforans*
" (d) *Flexor longus pollicis*
" (j) *Abductor pollicis*

Fig. 9. (ccc) *Lumbricales*
" (k) *Flexor ossis metacarpi pollicis*
" (l) *Abductor minimi digiti*
" (m) *Adductor* " "

Fig. 10. (k*) *Adductor pollicis; also fig. 5*

the fauces or gullet, and assists in closing it on the food passing down the œsophagus, on its way to the stomach.

There are three muscles that move the scapula, or shoulder-blade, upward and backward:—(1) The *trapezius* (Plate VI., *3*) is one of the most beautiful muscles of the body; the two conjoined, one on each shoulder and on the neck, extend from the tip of the one shoulder to the tip of the other, and from the nape of the neck down to the loins. When they reach the top of the neck they become tendinous, and are named *ligamenti nuchæ*, or ligaments of the neck. From this point down the neck the trapezius does not lay hold of the spine, but does so when it reaches the two last vertebræ of the back. It is implanted into more than one-third of the collar-bone next the shoulder, into the tip of the acromion or shoulder-top, and the whole length of the spine, from which the acromion rises. But its fibres, issuing from along the neck and back, and converging almost to a point, have very different effects, according to the different fibres that act. It moves and rolls the scapula, pulls the head backward, bends the neck, and is a powerful muscle of respiration. (2) *Levator scapulæ* (*21*) is a small thin slip of flesh, arising from the four or five uppermost vertebræ of the neck, by three or four and sometimes five distinct heads. These heads join to form a thin flat strip of muscle about 3 inches broad, which is fixed by a flat thin tendon to the upper corner of the shoulder-blade. This muscle pulls up the scapula when we shrug our shoulders. (3) *Rhomboideus* (*22*, *23*) arises first from the three lower spinous processes of the neck, and is implanted into the base of the scapula; and second, from the spinous processes of the first four vertebræ of the back, and runs into the base of the scapula. It has been sometimes reckoned two muscles, the major and minor. It raises the shoulder-blade, and carries it backward. The muscles that move the scapula forward come from the breast, upward from the neck, backward from the spine, and downward from the ribs.

Three muscles move the shoulder-blade downwards and forward:—(1) *Serratus major anticus* (Plate V., *tt*) arises from eight ribs, by distinct portions from each rib, and lies on the side of the chest. The distinct portions betwixt the ribs are called digitations or fingers; but the chief part of the muscle lies under the shoulder-blade, where it is thick and fleshy, and forms part of the cushion on which the scapula glides. It terminates in the whole length of the line, called the base of the scapula. When the entire muscle acts, it pulls the shoulder-blade downward and forward; when only the lower portions act, they pull the lower angle of the scapula forward; when the upper part acts along with the pectoral muscle, the tip of the shoulder is fixed and pulled towards the chest, and the lower corner of the scapula is rolled backward. But its most important action is to raise the ribs in breathing. (2) The *pectoralis minor* lies under the pectoralis major, close upon the ribs. It sometimes arises from the third, fourth, and fifth ribs; sometimes from the second, third, and fourth; and sometimes only from the third and sixth. Its three digitations are very thick and fleshy, and converge into a smaller muscle, terminating in a point attached to the apex of the coracoid process. It pulls the coracoid process forward and downward, and rolls the shoulders. (3) *Subclavius* takes its rise by a flat tendon from the cartilage of the first rib, and becoming fat and fleshy runs betwixt the first rib and the collar-bone. It is inserted along the whole clavicle, beginning about 2 inches from the sternum, and pulls the shoulder downward. The shoulder-blade is moved upward by the levator scapulæ and trapezius; backward by the rhomboideus, and the middle portions of the trapezius; downward and backward by the lowest order of fibres in the trapezius; downward and forward by the serratus major anticus; directly downward by the serratus, assisted by the subclavius, balanced by the trapezius; and directly forward by the pectoralis major, which is described below.

The arm is joined to the body by numerous powerful muscular ligaments. The muscles that move the shoulder-blade lie upon the trunk, those that move the arm lie upon the shoulder-blade, those that move the forearm lie upon the arm, and those that move the hand and fingers lie upon the forearm. But as the arm requires easy circular motions, it has a multiplicity of joints to perform them. It has the wrist, for turning it round; the elbow, for its hinge-like motions; and the shoulder-joint, on which it rolls. To assist all these the movable shoulder-blade becomes the centre of their motions, for after a certain point of elevation the motion of raising the arm is performed by the action of the scapula upon the trunk. When our shoulder-bone is raised to a horizontal position it is checked by the acromion or upper part of the shoulder-joint which hangs over it; and if we elevate our arm still higher, the scapula rolls, turning upon the point of the clavicle or collar-bone, and as it turns it glides easily upon those muscles which lie like a fleshy cushion betwixt it and that part of the trunk over which it is so usefully placed.

There are nine muscles employed in moving the humerus, or shoulder-bone:—(1) The *pectoralis major* (Plate V., *r*) is a large, thick, fleshy muscle, covering the whole of the breast. (2) The *latissimus dorsi* (Plate VIII., fig. 2, *b*) is the broadest muscle of the back, and largest of the body. These two muscles shape the arm-pit; the former, which constitutes the anterior border of the arm-pit, pulls the arm forward, lays it upon the breast, and supports loads laid on the arm; the latter, when the arm is raised, brings it downward, as we do in striking a blow with a hammer; or downward and backward, as when we knock with the elbow; or rolls the arm inward and backward, as when we turn the palm of the hand behind our back. The edges of these two muscles receive the pressure of the lame man's crutches. When both muscles act the arm is pressed directly downward, as when we rise from a seat or carry a bundle under the arm; and by their action we can raise ourselves over a beam by leaning on our hands. (3) The *deltoides* (Plate VIII., fig. 1, *c*) is the first of those muscles which arise from the shoulder-blade, and are inserted into the shoulder-bone or humerus; it is thick and fleshy, covers the top of the shoulder, and fills up the space betwixt the acromion and bone of the arm. It has three separate bundles of fibres, meeting about one-third way down the humerus, and forming a short, flat, strong tendon, almost surrounding the bone. The guards in fencing are chiefly performed by the three bundles of fibres belonging to this muscle, and they are also the most powerful rotators of the arm. (4) *Coraco-brachialis* (*i*, figs. 2 and 4) arises from the coracoid process of the shoulder-blade, and is inserted by a short tendon into the *os-humeri* (or arm-bone) nearly at its middle. Its action is to elevate the arm upward and forward, and to pull it towards the side of the body. It is therefore an imperfect rotator. (5) *Supra spinatus* (*d*, fig. 1) fills the hollow of the shoulder-blade above the spine, and is inserted into the upper part of the great tuberosity on the head of the shoulder-bone. Its action is to raise the arm directly upward, and at the same time elevate the capsule of the shoulder-joint. (6) *Infra spinatus* (*e*) is like the supra spinatus in every respect, and assists it in its action. (7) *Teres minor* (*h*, fig. 2) co-operates with the supra spinatus and infra spinatus, and assists them in raising the arm. (8) *Teres major* (*f*, fig. 1) is thicker and longer than the *teres minor*, and lies a little lower down on the edge of the shoulder-blade. It performs the same kind of rotation of the arm as the latissimus dorsi, and draws the humerus backward and forward. (9) *Subscapularis* (*g*, fig. 2) lines all the cavity of the shoulder-blade like a cushion, and assists the teres major and latissimus dorsi; it pulls the arm backward and downward, raises the capsule, and strengthens the joint. Those muscles which are implanted above the head of the shoulder-bone are designed to elevate the arm; and as the supra spinatus, infra spinatus, and teres minor are inserted into the great tubercle of the humerus, they must therefore raise the arm when they are in action. The deltoides, whose insertion is a little lower down than these, performs the same action with greater power; but, as the subscapularis is implanted into the opposite side, or lower part, of the head of the shoulder-bone, opposite the former muscles, it must draw the arm directly downward and backward. The pectoralis major and coraco-brachialis are inserted into the outer edge of the bicipital groove of the humerus, in one direction, and pull the arm inward, and towards the side, and forward. But as the latissimus dorsi and teres major are inserted into the inside, or lower part of the same groove, they pull the arm directly backward, and

roll the palm inward and backward. The shoulder-joint receives greater strength from its numerous muscles than its ligaments. The former are contractile, firm, and enduring; the latter elastic, yielding, and apt to rupture.

There are two flexor muscles for bending the forearm:—(1) The *biceps flexor cubiti* (*k*, figs. 2, 4, and 5), and (2) the *brachialis anticus* (*l*, figs. 4 and 5). There are also two extensor muscles that stretch the forearm:—(1) The *triceps extensor* (*j*, figs. 3 and 4), and (2) the *anconæus* (*m*, fig. 6). The uses of these four muscles are simply the flexion and extension of the forearm.

There are thirty-one muscles situated on the forearm for moving the radius (or its largest bone), the carpus (or wrist), and the fingers. These muscles perform supination, pronation, flexion, and extension. When we turn the palm of the hand down, it is called pronation; when we turn it upward, it is called supination. These motions are performed by rolling the radius (or large bone) on the ulna (or small bone) of the forearm. These thirty-one muscles comprise twelve flexors and nine extensors, and ten other muscles, varied in action, seated in the hand.

Of those thirty-one muscles (1) the *palmaris longus*, the *flexor carpi radialis* (*n*, fig. 5), and *flexor carpi ulnaris* (*o*) are the three principal flexors or benders of the wrist. (2) The *extensor carpi ulnaris* (*r*, fig. 6), the *extensor radialis longior* (*p*), and *extensor radialis brevior* (*q*) are the three principal extensors or stretchers of the wrist. (3) The chief pronators of the hand are the *pronator teres* (*a*, fig. 7) and the *pronator quadratus* (*b*). (4) The supinators of the hand are two: the *supinator longus* (*a*, fig. 6) and *supinator brevis* (*b*). (5) The long flexors of the fingers and thumb are the following:—*flexor digitorum sublimis perforatus* (*a*, fig. 5), *flexor digitorum profundus perforans* (*b*, fig. 8), the *lumbriciales*, four in number (*c c c*, fig. 9), *flexor longus pollicis* (*d*, fig. 8), and *flexor brevis pollicis* (*e*, fig. 5). (6) The extensors of the fingers are the *extensor communis digitorum* (*f*, fig. 6) and *extensor minimi digiti*. (7) The extensors of the thumb, the *extensor ossis metacarpi pollicis* (*g*, fig. 6), *primi internodii pollicis* (*h*, fig. 6), and *secundi internodii pollicis* (*i*, fig. 6). Three other muscles of the thumb are the *abductor pollicis* (*j*, fig. 8), *flexor ossis metacarpi pollicis* (*k*, fig. 9), and *adductor pollicis* (*k*, fig. 5). The little finger has also three muscles: *abductor minimi digiti* (*l*, fig. 9), *flexor minimi digiti*, and *adductor minimi digiti* (*m*, fig. 9). All the muscles that arise from the inner knob or condyle of the arm-bone are flexors. All those originating in the external condyle are extensors. Those inserted into the radius turn the wrist by rolling the radius on the ulna.

The whole of the back is covered with strong muscles related to the arms, ribs, and spine; but the muscles appropriated to the ribs, which perform no other function than respiration, are (1) the *serratus posticus superior*, which comes from the neck, extends over the ribs, and pulls them downward. (2) The *serratus inferior posticus*, which comes from the vertebræ of the loins, lies flat on the lower portion of the back, and pulls the ribs downwards. (3) The twelve *levatores costarum*, which arise from the transverse processes of each vertebra of the back; and each muscle going down to the rib below, raises it up when in action. (4) The *intercostal muscles*, external and internal, fill up the spaces, crossing each other betwixt the ribs, and raise and depress the chest in respiration; to these may be added the *triangularis sterni*, a muscle that lies within the chest, and pulls the ribs downward. The muscles of the ribs are appropriated to respiration, and unite their functions with the diaphragm and muscles of the abdomen. In coughing, sneezing, speaking, smelling, &c., there are other muscles besides these which are also brought into action, belonging to the locally affected or irritated parts.

There are seven posterior muscles of the head and neck yet undescribed: (1) *splenius*, (2) *complexus*, (3) *trachelo-mastoideus*, (4) *rectus minor*, (5) *rectus major*, (6) *obliquus superior*, (7) *obliquus inferior*. All these muscles more or less assist each other. The splenius, acting singly, turns the head obliquely to one side; but when both act they pull the head downward. The complexus and trachelo-mastoideus, rectus major and minor, perform nearly the same action as the splenius. The obliquus superior and inferior perform the short quick turnings of the head.

The posterior muscles of the trunk form the greater portion of the fleshy substance of the back: (1) *quadratus lumborum* (Plate IX., fig. 1) keeps the trunk erect, inclines it to one side, turns it on its axis, pulls down the ribs, and assists respiration; (2) *longissimus dorsi* (Plate VI., *26*) keeps the trunk erect, and bends the spine backward; (3) *sacro-lumbalis* (Plate VI., *27*) takes a firm hold of the ribs, and not only pulls them down, but also assists in raising the trunk; (4) *cervicalis descendens* turns the neck to one side and bends it; (5) *transversalis colli* lies between the trachelo-mastoideus and cervicalis descendens.

The surface of the back, betwixt the bulge of the ribs on each side of the chest, consists of innumerable hollows, processes, and points of bone; it is tied from point to point, and its hollows are filled with unequal bundles of tendon and flesh. The first bundle is divided into two sets, called (1) *spinalis cervicalis* and (2) *spinalis dorsi* (Plate VI., *25*). It lies along the whole length of the neck and back, and raises the spine. The second bundle is called *semi-spinalis dorsi;* the third, *multifidus spinæ*, keeps the spine from bending too much forward; the fourth and fifth, *inter-transversalis* and *inter-spinalis*, are useful in assisting us to perform the lateral and twisting motions of the loins. There are other two bundles, called *inter-transversalis-cervicis*, and *priores-lateralis*, which complete the total number. All these muscles render the back, but especially the spine—which they clothe with flesh—firm, smooth, and elastic.

There are other five muscles, lying on the fore part of the head and neck, which complete the catalogue of the muscles belonging to the spine: (1) *rectus internus capitis major*, (2) *rectus internus minor*, (3) *rectus capitis lateralis*, (4) *longus colli*, (5) *scalenus*. The first four muscles pull the neck to one side when acting singly; but when acting doubly, they bend down the neck and head. The scalenus throws the head backward, that the chest may be more powerfully raised in coughing.

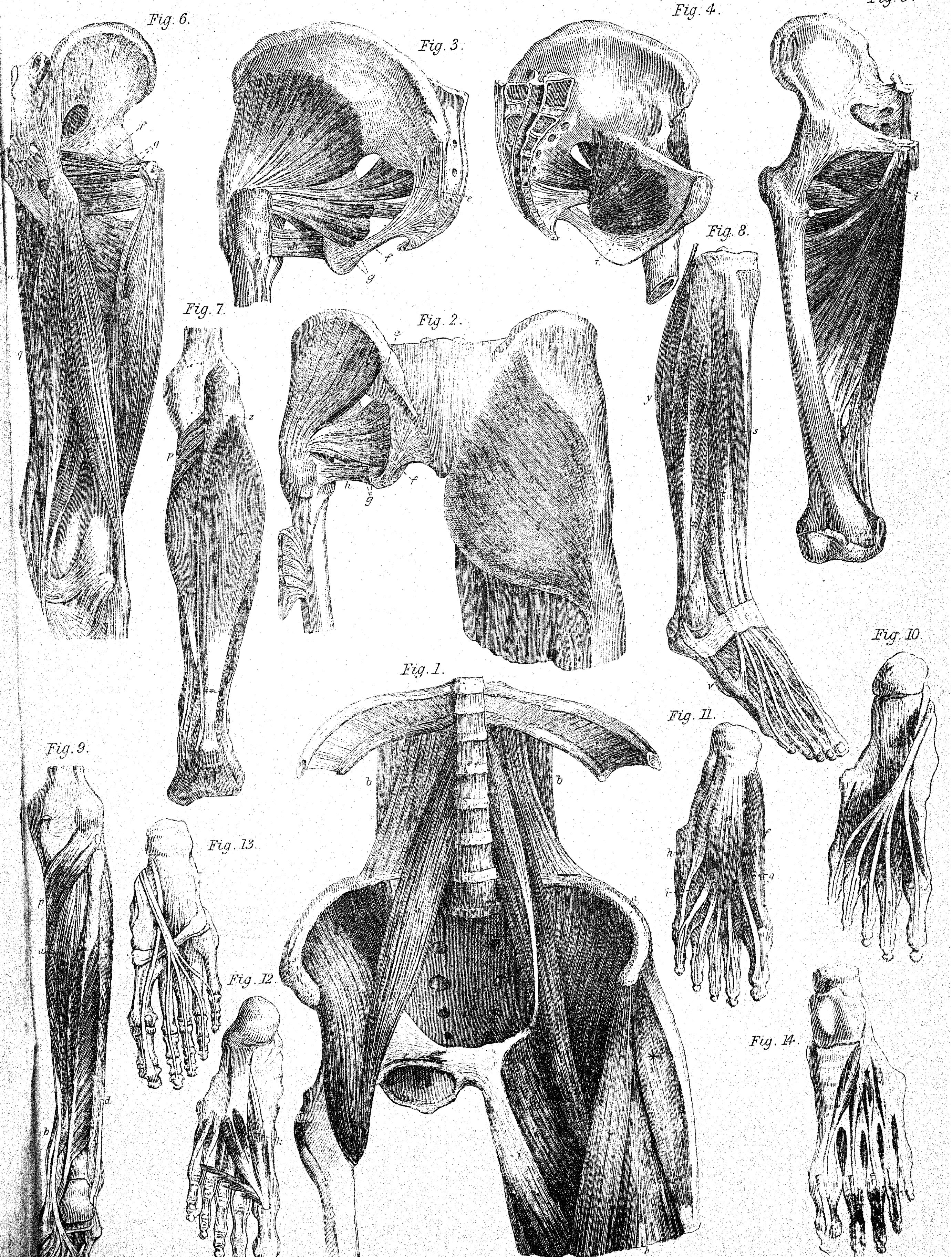
The muscles of the abdomen or belly are five on each side: (1) *the obliquus externus descendens* (Plate V., *v v*), on each side, covers all the abdomen with its fleshy fibres, and also the fore part of the abdomen with its white expanded tendon; its fibres run obliquely from above downward and inward. (2) The *obliquus internus ascendens*, within the last muscle, arises chiefly below in the haunch-bone, and all its fibres run from below upward. (3) The *transversalis* lies under all the other muscles next the abdominal cavity; its fibres run across and round the abdomen. (4) The *rectus* (Plate V., *w w*) runs on the fore part of the belly, in a straight line from the os-pubis, or share-bone, to the sternum or breast-bone. (5) The *pyramidalis* (Plate V., *x x*) is a small conical muscle, arising from the os-pubis, and having its apex turned upward.

These five abdominal muscles make an external covering. They support and contain the bowels. They also bend and turn the trunk, and fix it firmly for the stronger action of the limbs. They keep the body steady in raising weights, bearing loads, and, alternately with the diaphragm or midriff (that internal muscle which separates the abdomen from the chest), they perform respiration. When the diaphragm presses down the bowels and enlarges the chest we inspire, *i.e.* draw in our breath; when the abdominal muscles react and push back the diaphragm, the chest is compressed, and we let out our breath.

The two oblique muscles on one side, when in action, turn the body on its axis. But when they act on both sides, they co-operate with the rectus muscle in flattening the abdomen and bending the body. The recti muscles pull the ribs downward in breathing, flatten the body, and bend it forward. The transverse muscles tighten the linea alba. The *linea alba* (Plate V., *z*) is the common meeting of all the white, thin, flat tendons of the abdominal muscles in the centre of the belly, and forms the point toward which they all act; the *linea semilunaris* (Plate V., *y*) is a white circular line, produced by the meeting of all the tendons of the abdomen on the edge of the rectus to form its sheath, and is called the sheath of the rectus muscle; the *umbilicus* or navel is an opening in the centre of the belly or the middle of the linea alba.

PHYSIOLOGY.

MUSCLES OF THE LOWER LIMBS.



REFERENCE TO PLATE IX.

Fig. 1. (*) Tensor vaginæ femoris.
„ (*aa*) Vertebro-iliacus.
„ (*b*) Quadratus lumborum.
„ (*j*) Pectineus.
„ (*r*) Sartorius.

Fig. 2. (*b*) Gluteus maximus.
„ (*c*) Gluteus medius.

Fig. 3. (*d*) Gluteus minimus.
„ (*e*) Pyriformis; also *fig. 4.*
„ (*g*) Gemini; also *fig. 6.*
„ (*h*) Quadratus femoris; also *fig. 5.*

Fig. 4. (*e*) Pyriformis; also *fig. 3.*
„ (*f*) Obturator internus.

Fig. 5. (*h*) Quadratus femoris; also *fig. 3.*
„ (*i*) Obturator externus.
„ (*k*) Triceps adductor femoris.

Fig. 6. (*g*) Gemini; also *fig. 3.*
„ (*m*) Semi-tendinosus.
„ (*n*) Semi-membranosus.
„ (*o*) Biceps flexor cruris.
„ (*q*) Gracilis.

Fig. 7. (*p*) Popliteus.
„ (*z*) Plantaris.

Fig. 8. (*s*) Tibialis anticus.
„ (*t*) Extensor longus digitorum pedis.
„ (*u*) Extensor proprius pollicis.
„ (*w,x*) Peronei.
„ (*y*) Gastrocnemius.

Fig. 9. (*a*) Flexor longus digitorum pedis perforans.
„ (*b*) Tibialis posticus.
„ (*d*) Flexor longus pollicis.
„ (*v*) Extensor brevis digitorum pedis.

Fig. 10. (*c*) Flexor digitorum accessorius.

Fig. 11. (*e*) Flexor brevis digitorum pedis perforatus.
„ (*f*) Abductor pollicis pedis.
„ (*g*) Flexor brevis pollicis pedis.
„ (*h*) Abductor minimi digiti.
„ (*i*) Flexor brevis minimi digiti.

Fig. 12. (*j*) Transversalis pedis.
„ (*k*) Adductor pollicis pedis.

The *diaphragm* or interseptum is an internal transverse vaulted partition betwixt the abdomen and chest; it is not only vaulted in the middle, but rises as high anteriorly as the breast-bone, where it commences; while its lower and back parts begin almost as low as the pelvis, and from the false ribs and the vertebræ of the loins. Although it is convex towards the chest and concave towards the abdomen, yet it becomes almost plane when it presses against the abdominal muscles in inspiration, but resumes its convexity when by their reaction it is pushed back again into the chest in expiration. Strictly speaking, there are two diaphragms—a greater before and a smaller behind; in the centre betwixt them is a strong triangular tendon, and in the fleshy and tendinous fibres there are several natural openings for the transmission of bloodvessels, ducts, and nerves, betwixt the abdomen and the chest. Haller has justly said, "The diaphragm is the noblest muscle after the heart."

The muscles that move the thigh-bone are fourteen. (1) *Tensor vaginæ femoris* (Plate IX., fig. 1*), (2) *psoas magnus* (*a a*), (3) *psoas parvus*, (4) *iliacus internus* (*a**), (5) *pectineus* (*j*, fig. 1), and (6) the *triceps femoris* (*k*, fig. 5), which is subdivided into the three branches, *adductor longus*, *adductor brevis*, and *adductor magnus*. These six muscles move the thigh forward, and point the toes inward. The psoas magnus and iliacus internus are inserted into the trochanter major of the thigh-bone, and the pectinalis and triceps into the linea aspera. The first three of the remainder of these fourteen muscles are—(7) the *glutæus maximus* (*b*, fig. 2), (8) *glutæus medius* (*c*, fig. 2), and (9) the *glutæus minimus* (*d*, fig. 3). These three move the thigh-bone backwards and outwards. The glutæus maximus is inserted into the linea aspera; the glutæus medius into the trochanter major, and glutæus minimus into the top of the trochanter. The remaining five muscles are:—(10) the *obturator externus* (*i*, fig. 5), (11) the *gemini* (*g*, figs. 3 and 6), which some anatomists subdivide into two, (12) the *obturator internus* (*f*, fig. 4), (13) the *quadratus femoris* (*h*, figs. 3 and 5), and (14) the *pyriformis* (*e*, figs. 3, 4). These five move the thigh-bone backward, and roll it on its axis. The obturatores externus and internus, the pyriformis, and gemini are inserted into the root of the trochanter and the quadratus, betwixt the trochanters. These fourteen large fleshy muscles together assist in forming the contour of the thigh, and perform many of its most powerful and useful actions.

There are four muscles that extend the leg:—(1) The *rectus femoris* (Plate V., B), (2) *cruræus*, (3) *vastus internus* (D), and (4) *vastus externus* (C). These large muscles assist in forming the thigh, and are all inserted by one strong tendon into the patella or knee-lid. But the vastus externus and internus also send some fibres to be inserted on the outer part of the head of the tibia or great bone of the leg. The knee being a hinge-joint these four muscles extend the leg, bend the thigh on the trunk, and are the great agents in running, leaping, and walking. There are six flexor muscles that bend the leg:—(1) The *sartorius* (*r*, fig. 1, Plate IX.) or tailor's muscle, by which the legs are crossed, (2) *gracilis* (*q*, fig. 6), (3) *semitendinosus* (*m*, fig. 6), (4) *semimembranosus* (*n*, fig. 6), (5) *poplitæus* (*p*, fig. 7), and (6) *biceps cruris* (*o*, fig. 6). The first four are inside flexors, and their tendons are inserted into the rough head of the tibia or large bone of the leg; they also form the hamstrings, and extend their flattened expansions downward upon the leg. The tendon of the biceps is inserted into the upper knob of the fibula or small bone of the leg, and the poplitæus is inserted broad into a ridge on the back part of the tibia. These muscles form part of the fleshy and tendinous substance of the ham and thigh.

There are six extensor muscles for the movement of the foot; the first four, viz. (1) the *gastrocnemius* (*y*, figs. 7, 8), (2) the *plantaris* (*z*, fig. 7), (3) the *solæus*, and (4) *tibialis posticus* (*b*, fig. 9), lie on the back part of the leg; and the last two, viz. (5) the *perinæus longus* (*w*, fig. 8) and (6) *perinæus brevis* (*x*, fig. 8), lie on the outside of the leg. These extensor muscles are useful in running, walking, and leaping. There are also two flexor muscles of the foot, which, lying on the fore part of the leg, when acting together bend it, viz. the *tibialis anticus* (*s*, fig. 8) and the *perinæus tertius*. The tendon of Achilles (that thick cord which is attached to the heel-bone, and forms the lower part of the hinder portion of the leg) is formed by the union of the solæus and gastrocnemius muscles. There are sixteen muscles of the toes that move them in every direction—their names generally denote their uses: flexion, extension, abduction, and adduction, are performed by their action. (1) *flexor longus pollicis* (*d*, fig. 9), (2) *flexor longus digitorum pedis* (*a*, fig. 9), (3) *massa carnea* (*c*, fig. 10), (4) *flexor brevis digitorum* (*e*, fig. 11), (5) *lumbricalis*, (6) *extensor longus digitorum pedis* (*t*, fig. 8), (7) *extensor digitorum brevis* (*v*, fig. 14), (8) *extensor pollicis proprius* (*u*, fig. 8), and the crucial ligaments, (9) *abductor pollicis* (*f*, fig. 11), (10) *flexor brevis pollicis* (*g*, fig. 11), (11) *adductor pollicis* (*k*, fig. 12), (12) *transversalis pedis* (*j*, fig. 12), (13) *abductor minimi digiti* (*h*, fig. 11), (14) *flexor brevis minimi digiti* (*i*, fig. 11), (15) *interossei interni* and *externi*. (16) The *plantaris aponeurosis*, which is a thick membranous expansion, defends the sole of the foot and protects the bloodvessels, muscles, and nerves lying under it from external injury.

The flexors and extensors, the adductors and abductors of the toes, are antagonist muscles; the flexors bend the toes downward, the extensors raise them upward; the adductors draw them inward, and the abductors outward. And much in the same manner the antagonists of the leg also act upon the foot, and move it by the ankle-joint in every possible direction. The mechanism of the leg and foot is beautiful and perfect, and nothing that science has invented can equal its elegance and utility. By the simple and combined action of a few bones and muscles we climb, walk, run, leap, dance, &c., and perform innumerable graceful and extraordinary feats.

On some parts of the body—particularly the temporal muscles, the abdomen, the back, the arms, and thighs—a strong broad *fascial* (*i.e.* sheet-like) membrane is spread. This is done to protect, cover, and give them firmness. This partial covering, by its gentle and powerful expansion, defends the internal parts from injury, and facilitates muscular motion. The human body, in a healthy state, is powerful or weak in proportion to the strength or exhaustion of the muscles. Muscular exercise increases muscular power; muscular inaction produces muscular debility. If muscles are actively and constantly employed, they become more powerful than if accustomed to inactivity and rest. The brawny muscles of a blacksmith's arm are stronger than those of a lawyer's clerk.

The muscles, as we have said, are the organs of locomotion. They plainly fall into two great classes—(1) voluntary, and (2) involuntary. They might almost also be classed as (1) external, and (2) internal. We have described each in considerable detail, and we present to the student Engravings of them which will help him greatly to understand the positions and functions of the most important muscles of the body. It would, of course, be impossible to represent every muscle in these illustrations without greatly exceeding our limits. Of those muscular parts of the frame which are not used in bringing about change of place, but are employed in effecting interchange of matter, and are not (in any great measure, at least) amenable to the will, we shall have to say something further hereafter. The heart is the chief of these agents, and the arteries aid it in carrying on its systemic specialty. The middle coat of the arteries, and the entire heart, are muscular; and pulsation is accomplished by their elastic power, stimulated by the circulating blood. The middle coat of the stomach and bowels is muscular, and every person knows how speedily death is sometimes produced by its painful spasms.

The muscular system, like other parts of the body, possesses the faculty of conservation and self-reparation. The muscles perform their vital functions, and extract from the blood the individual elements only—mainly albuminoid material—that are required for their necessities with order, promptitude, and facility. We ought never, by overstrained exertion, to injure the tissue or tone of our muscles. When, however, a muscle is exhausted or lacerated the circulating blood deposits the necessary elements to preserve and repair it. In either case the blood supplies the elements necessary to the formation of muscle-fibrin fitted for its growth and preservation.

BOOK-KEEPING.—CHAPTER III.

ADAPTATION OF BOOK-KEEPING TO AGRICULTURE—HEADINGS OF ACCOUNTS—FORM OF A STOCK-BOOK AND CASH-BOOK FOR A FARM.

Mr. W. Stivenson, at one time a merchant in Amsterdam, who subsequently became a somewhat famous teacher of book-keeping in Edinburgh, and published, in 1762, among other works on the professional pursuit in which he was then engaged, a "System of Farm Book-keeping," laid it down as a maxim, "that no man can compose a right set of fictitious books for a merchant but he who has been concerned in real trade; none that for a gentleman's estate but he who has an estate of his own; none that for a farmer but he who has dealt in real farming; and all the three ought to understand the principles of book-keeping thoroughly." Of the perfect appropriateness of the statement contained in the last clause there can be no doubt, and few would be found inclined to deny its wisdom or dissent from the acknowledgment of its truth. But if the experience of nearly a century and a quarter, which has elapsed since Stivenson wrote, is worth anything as a guide to what we may expect in the future, the progress of book-keeping as a study would appear to have little chance of attaining what was deemed most essential to its furtherance, for very few merchants, landed proprietors, or farmers have shown much inclination to enter upon the office of instructors of those busied with affairs—commercial, rural, or agricultural—in the practical application of book-keeping to their special pursuits. Such gentlemen, if prosperous and successful in their avocations and employments, are likely to be too much engrossed with the practical concerns demanding their constant attention to bestow much toil or time on the working out and perfecting of theoretical schemes of book-keeping for the benefit of others, and therefore little inclined to embarrass their minds with the labours and risks of authorship; and any gentleman belonging to these classes who, on being unsuccessful in the pursuits which his position necessitated, should appear as a teacher of the best method of insuring the safety and success of mercantile business or agricultural transactions, so far as book-keeping is concerned, would not present himself under the most favourable circumstances to the public. It appears, therefore, that in this, as in other branches of study, theoretical teachers must—more especially in these days of the thorough adoption of the system of division of labour—continue to propound their principles, that by them others may govern their practice, even though—perhaps just because—they have not been engaged in real trade, have no estate of their own, and have not dealt so much in farming lands as in informing minds.

The *principles* of a subject are that body of well-ascertained truths by which the proper practice of any art or science is regulated. The principles remain the same, however much the material subjected to their operation may differ. It does not make any alteration in the principle of keeping accounts that the things dealt in or requiring to be computed differ. It is a matter of no importance at all, so far as the book-keeper's business with the affair is concerned, whether the entries in his cash-book refer to horses, hogs, barley, rye, and wheat, or to hats, umbrellas, books, ironmongery, or cloth. His share in the transaction is the accurate recording and due accounting for what the articles cost as outlay or bring as income. In the same way the sales-book of a draper and a farmer vary immensely in regard to the things bought and sold; but as to the main matter, of precisely recording what has been received for sale and what has been realized by their sale, however much the figures in which the accounts are kept may differ, they do not differ at all in the essential principle of duly and truly recording and summarizing all that has been received and all that has been parted with—everything that has come in and gone out. The person who sets forth explanatorily the principles of book-keeping for the attainment of the most accurate and trustworthy, as well as the readiest and least troublesome, mode of fulfilling the responsibility of this duty, may not know the precise price of live stock, may blunder egregiously in quoting the cost of eggs, butter, flour, or ploughs at sums greatly differing from the ordinary market value of the things named, and others like them; but though the sums (imaginarily) received or paid for these articles may be preposterously wide of the mark, the way of dealing with them as sums—that is, the principles of accounting for either these articles or their money's worth—will be equally the same as if the quotations made coincided with the current market list in yesterday's newspaper, or agreed with the latest priced catalogue of seedsmen or agricultural implement makers or their agents in any town in the kingdom.

The chief difficulty in farm book-keeping is one which has no reference whatever to the principles of calculation in themselves. It is a difficulty of classification, of arranging, under distinct, clear, and adequate headings, all the separate multifarious items of plant, implements, furniture, seeds, produce, labour (indoor and outdoor, constant or occasional), poultry, dairy, and garden cost and gain, cartage, steam-work, feeding stock, working stock, field input and output, &c., which require to have places assigned to them in the farmer's mind, and accounts contrived to overtake each without omission of any or overlapping of some. The accounts require to be so precisely and specially subdivided that each shall distinctly exclude the other, and leave no doubt under which heading any particular item of outlay or gain should be placed, and yet they must be so complete and extensive (without being perplexingly numerous) as to include all the affairs involving charge and discharge, profit and loss, that can arise in each peculiar farm. It is obvious that no mere theoretical classification can be contrived which will suit all the exigencies of practical farm life, giving them each their due place in proportion to their importance in actual husbandry. The nature of each farm as to extent, situation, soil, cropping, store, nearness to or distance from markets, abundance or scarcity of labour, and many other (conceivable) differences, necessitates the adoption of specialties of working, seeding, stocking, buying, selling, &c., which make one arrangement of accounts preferable to another in distinct farms. Precisely the same practical difficulty arises in mercantile as in agricultural life. Differing businesses, distinctions of trade outlet, multiplicity or fewness of articles dealt in, each and all require an adaptation of books used and system of book-keeping pursued, but yet the principle on which the books are kept is unaltered. Undoubtedly the securing of a certain and systematic division and arrangement of account-headings at once comprehensive and co-exclusive is a most important element in the successful management of either commercial or agricultural book-keeping, but that depends rather on the mind and culture of the merchant or farmer than the system of the book-keeper.

The matter necessitating book-keeping and yielding the entries to be distributed into the various books for registration, arrangement, and ultimate balancing is, of course, quite different from that dealt with in other branches of commerce and industry; and the details of entry, form, arrangement, check, and countercheck, are necessarily unlike those of what are more generally regarded as mercantile concerns. It is certain, however, that farming is in just as much need of good, plain, precise, and easily practised methods of accounting as any other form of industrial and commercial undertakings. The expenditure in rent, taxes, insurances, stock, labour, household, &c., requires to be estimated, registered, and balanced against income from husbandry, grazing, dairy produce, poultry, live stock, and other sources, so that not only their relation one to another may be seen, but that the exact relation of the cost to the produce of each may be readily found, and, being brought into view, may be regulated for the general good of the estate in accordance with its position, as encouraging or discouraging, in the profit and loss account. The avocations of farmers are so various, and the nature and kind of farms so different, that there must be a great many possible forms in which the several accounts may be classified, and of headings under which the entries may be made. In large farms very minute subdivisions may (and probably would) be necessary, and a large number of distinct forms may be advisably employed to secure that accurate accounting which the great interests involved in such extensive undertakings demand; while in small farms a less num-

ber—each including more classes of items under it—might perfectly well answer the purpose. It is never to be forgotten, however, that the more minute and definite the classification of entries can be made—unless cumbersome in their details and difficult in the calculations they involve—the clearer the view of the state, progress, and loss or gain of each of the separate interests relative to the whole really becomes. One farmer, for instance, may be contented to arrange a given series of transactions under the single heading grain; another might distribute this under the separate headings of wheat, oats, barley, beans, pease, or beans and pease combined. So, one may keep under one heading—live stock—all that related to stock bought, stock sold, stock bred, losses of stock, stock taken in to feed, stock sent out to feed, &c. These are matters which may safely be left to the judicious thoughtfulness and growing experience of a man who recognizes the one vital principle, that the cost price of an article includes all that has in any way been expended upon it (money or money's worth) to bring it from what it was to what it had become when it was sold, or otherwise parted with; and that the profit gained upon an article is the difference between the price got (with all the expenses and disbursements, direct and indirect, attendant on its sale) and that cost price, and who therefore takes care to note down and distribute aright, all over head, not only all that he receives, but everything that he disburses. All accounts are kept either of (1) money, or (2) of money's worth, *i.e.* stock, property, or possessions of every possible kind having exchangeable value. The latter, whether consisting of seed, grain, growing crops, meals, &c., or implements, utensils, furniture, live stock, &c., having all cost cash, and being all (regarded as) convertible into cash, may be (and often must be) kept account of only as commodities until, if at any time, they are so converted. All movements made in them, all transfers of them, all increase in or depreciation of their cost or value, must be noted and calculated until they disappear from consideration either by loss, use, barter, or sale; in the two latter of which cases they reappear as goods, *i.e.* property or money. Book-keeping looks on every transaction as a case of charge and discharge, expenditure and income. The plainest idea that can be entertained of its nature is to look upon each single account as the (ideal) note-book of a separate individual dealing in and taking care of one specialty, in connection with which he is responsible for the due and right acknowledgment of all he receives, and the accurate and proper registration of all that he parts with. Be it, then, grain or live stock, merchandise or labour, "In" is reckoned *Dr.*, "Out" *Cr.* Each of the (possible or) real separate accounts being, in this way, regarded as a distinct account kept (in idea) by a different responsible person who really has (or is supposed to have) the charge of the particular item, whatever it may be, to which the account refers, the book-keeper notes down all that he gets in and all that he gives out, and can at any moment *tot up* how the affairs intrusted to his hands are, and how they have prospered—whether he is more advantageously or less advantageously situated at any present than at any past time, *i.e.* whether there has been profit or loss in his department.

Systematic nomenclature and definite accuracy in the division of things really require and imply (1) a wide acquaintance with the words used in any art, science, or pursuit; (2) a clear apprehension of their meaning in ordinary as well as in technical usage; (3) a fixed and well-defined perception of what is comprehended in the words employed, so that what is to be included under each expression may be easily and rightly understood, and what is to be excluded from consideration when a word is used may be quite well known, being neither too narrow to embrace all that is intended to be covered by it, nor too wide to permit indecision upon what should be entered under it; (4) an adequate and complete perception of the co-ordination or subordination of every term specially adopted, distinguishing essential from accidental signification; and (5) such an orderly arrangement of all the component parts of a subject as shall enable the person who understands both the subject and the language to bring together through them an exact and complete statement of all that has happened to and been done with whatever matters are expressed by the words, so that the record made of the changes which have occurred shall exactly correspond with the precise condition of those things to which it refers.

A little difference may be necessary in the words used and the conventional meanings attached to them, in a mercantile concern and in agricultural pursuits; but the operations to be performed are similar, however distinct the articles dealt in, or the names they receive. As, in farming, it is usual to speak of the sheep, cattle, horses, swine, &c., kept, fed, and bred on the land, as stock, it would perhaps be advisable to use the word capital instead of stock, to denote the whole property in money, goods, &c., invested and employed in the farm; or to distinguish the special department of property by some such title as "live stock," and to have, in subordination to this general title, a sub-heading for horses, (1) for farm work, (2) for family use; horned cattle—oxen, bulls, cows, (1) for farm use, (2) bred for sale, and (3) dairy; sheep and lambs in their different sorts—Cheviots, Blackfaced, Leicester, Ryland Forest, Gloucester, Welsh, Iceland, South Downs, &c.; swine and hogs, &c. The heading "land" might have as subordinate divisions, arable, grass, wood, pasture, garden, and fallow ground. Produce may be subdivided under such titles as grain, green crops, and fruit and garden stuff, or wheat, oats, barley, rye, maize, hay, clover, pease and beans, turnips, mangel-wurzel, potatoes, beet, &c.; dairy would have its items classified as milk, butter, cheese; poultry, as fowls and eggs; implements, a sub-reference to those of (1) tillage, including ploughs, harrows, grubbers, rakes, hoes, rollers, clod-crushers, spades, &c.; (2) cultivation, as dibbles, drills, top-dressers, manure-distributors; (3) harvesting, comprising reaping, haymaking, raking, threshing, winnowing, dressing, and other machines, to be used by horse or steam; (4) stock-feeding, as turnip and chaff-cutters, pulping machines, crushers, grinders, bruisers, parers, &c.; (5) general work, marketing-carts, waggons, barrows, &c. Other departments, like draining, irrigation, manuring, might also require separate headings. The expenditure of the household and of the farm would be kept apart. The cost of tillage and the result in produce of each distinct field, in its special rotation, would probably be most advantageously recorded in distinct accounts. It is, in general, a mistake to have vague headings like "sundries," "miscellaneous expenses," &c., because it is difficult to divide and estimate how much of the items entered under those is applicable to each special department of farm industry, and to apportion it fairly when only thus noted in slump. There will necessarily be some such headings for incidental things not readily definable and sometimes even unforeseen; but as many specific accounts should be fixed upon as should keep these very indefinite accounts from getting quite unmanageable because of the variety of entries they include. The "miscellaneous" may be rendered less so by judicious assortment, such as, opening separate accounts entitled miscellaneous produce bought, miscellaneous produce sold or used; wages, (1) hired servants, (2) occasional labourers, such as harvest hands; stock taken in to pasture, stock sent out to pasture; live stock bred, live stock died, sold, or used; seeds bought, seeds sold; tradesman's bills for (1) farm, (2) household; servants' rations, &c. (1) indoor, (2) outdoor; and a number of others which, being extricated from the miscellaneous, would lighten the columns appropriated to these somewhat vague entries, and would show more clearly what had been profitably laid out and what otherwise.

As an example of how even such accounts fall to be dealt with according to the leading principles of book-keeping—Received Dr., Given out Cr.—we give on the following page a table—the items of which, though purely imaginary, are sufficiently illustrative—as a specimen of a Live Stock Account—Sheep. On this account the following remarks may be made:—On the Dr. side the 55 lambs having been received into the live stock without any actually calculable outlay of cash, no cash cost has been introduced on their account. When, however, they are transferred into the next month's live stock account they would have a money value attached to them, and whoever was responsible for

them would enter them as "stock valued as under"—giving their designation, placing their number in the lambs' column, stating the rate at which they are valued, and noting their cash worth in the money columns.

Dr. SHEEP (*Charge*).

1898.	Date.		Tups.	Wedders.	Ewes.	Lambs.	Rate.			
							s.	£	s.	d.
May	15	To Stock valued as under—								
"	"	" 1 South Down Ram, . .	1				126	6	6	0
"	"	" ½ Score Gimmers, . . .			10		72	36	0	0
"	"	" 1 Score Dinmonts, . . .		20			35	35	0	0
"	"	" Blackfaced Wedders, . .		25			44	55	0	0
"	"	" " Ewes, . .		30			40	60	0	0
"	"	" " Lambs, produce of stock (Tups),				25				
"	"	" " Lambs, produce of stock (Ewes),				30				
			1	75	10	55		192	6	0
		" Balance [(1) of stock, (2) of cash], ...	1	52	3	40		121	10	6

SHEEP (*Discharge*). Cr.

1898.	Date.		Tups.	Wedders.	Ewes.	Lambs.	Rate.			
							s.	£	s.	d.
May	20	By Family Supplies, charged		3		1	30 & 16	5	6	0
"	"	" Farm " "			6	3	25 " 12	9	6	0
"	"	" Early Lambs sold to A. Maxwell, butcher, .				9	15	6	15	0
"	"	" 1 Ewe died and 2 Lambs worried, ...			1	2				
"	27	" 12 Blackfaced Wedders,		12			50	30	0	0
"	"	" 8 Dinmonts, ...		8			42	16	16	0
"	"	" 12 Stones wool, 27*s.*; 6 inferior, 18*s.*; hides, &c., 7*s.* 6*d.*, . . .						2	12	6
"	30	" Balance [(1) of stock, (2) of cash], . .	1	52	3	40		121	10	6
			1	75	10	55		192	6	0

On the Cr. side the charge made for live stock for family and farm respectively are at a lower than market rate—because that is supposed to include allowance for profit, expense of sale, &c., which these have not required to be debited with. This may be considered as being only the prime cost of the animals used.

Under date 20th May there are losses noted—this is done to keep the account of the live stock right; but as no money was received for them no money has been entered, and such an entry would fall to be dealt with in Profit and Loss—Live Stock.

The balance of 30th May does not require the words bracketed to appear in a set of books. They are here inserted as explanatory of the double entry made in the opposite columns.

Without at all committing ourselves to the prices of things as marked, and with perfect confidence in the principles of book-keeping, we propose to supply the form of a farm cash-book, and to show that it is kept on exactly the same plan as that of a merchant's or tradesman's—except that the matters introduced into it differ in name, price, &c., as they in point of fact do in every set of books. Of course the cash-book is entirely concerned with noting, collecting together, and arranging into one account all ready-money transactions. Moneys received are, as promptly as possible, written down on the Dr. side, and all disbursements or cash paid out are placed on the opposite or Cr. side. The difference between these two sides, when made up, indicate the balance. For greater simplicity we suppose this cash-book to be kept for the farm alone—in so far as it is a trade investment, requiring note of profit and loss—and quite distinct from that of the household or family expenses book—which would, however, be kept in precisely the same manner as that of which a specimen was given in the preceding chapter (p. 136).

Dr. FORM OF A FARM CASH-BOOK. Cr.

1898.			£	s.	d.	£	s.	d.
May	3	To Balance from last month, . . .				111	12	8
"	5	" Barley sold to George Walters, .				15	4	0
"	6	" Gray pony sold to George Walters,				17	10	0
"	11	" Swedish turnips (22 tons), . . .	0	10	3	11	0	0
"	"	" Scotch yellow turnips (50 tons), .				22	1	0
"	12	" Wool sold to D. Matthews, . .	0	12	6	20	14	6
"	"	" Four lambs sold to A. Cairney, .	0	8	4	4	4	0
"	"	" Barley sold (seed) to P. Fraser, .				43	14	0
"	15	" Oxen sold to Richard Wyatt, . .				29	0	0
"	"	" Rents for farm cottages, . . .				10	10	0
"	"	" Royal Bank, ...				408	0	0
"	"	" Rents, land sublet, ...				13	5	0
"	21	" Hides and calf skins, ...	0	6	3	4	15	0
"	27	" Winter pasture—seven payments,	3	3	4	36	8	0
"	30	" Meal—to sundries, ...				7	6	0
"	"	" Dairy produce for month, . . .	0	0	3	3	18	7
"	"	" Bill receivable (No. 3) J. A. Watson,				33	7	9
"	"	" Discounts, ...				3	12	3
		Balance—cash in hand, £91 12s.	5	0	11	796	2	9

1898.			£	s.	d.	£	s.	d.
May	4	By Cash—Alex. Donald for dyking,				9	14	3
"	"	" " D. Corbet for draining, .					5	8
"	"	" " J. Gellatly for trenching,				8	6	2
"	"	" " Servants' calves bought, .				3	0	0
"	7	" " A. F. Donald—repairing garden wall, ...				1	11	2
"	11	" " Farm expenses—petty cash,				3	19	7
"	14	" " Gig horse bt. of J. Connell,	2	18	0	42	18	
"	15	" " Half year's rent, . . .				385	0	0
"	"	" " Servants' wages—half year,				114	18	0
"	"	" " 122 days' labour, . . .				14	4	8
"	"	" " Coals—5 tons, 12s. 6d.; 7 tons, 16s., ...				8	14	6
"	18	" " New cart and plough, . .	0	10	0	10	10	0
"	"	" " J. Doughty, blacksmith—half year's account, . .	0	4	3	13	7	9
"	"	" " Market incidentals, . .				1	13	3
"	26	" " Bill payable (No. 7) P. Horner, ...				27	9	2
"	30	" " Family expenses, . . .				53	17	8
"	"	" " Discounts, ...				5	0	11
"		" " Balance, ...				91	12	0
			3	12	3	796	2	9

As in business, so in agriculture, some people prefer to keep their cash-book on one side only, and by the use of double-money columns avoid the difficulty of passing from side to side in making the entry. The principle, however, is still the same. Sums of money received are put in one column, and require to be kept distinct from sums expended, which are put in another column, and these columns are separately headed Dr. and Cr. In this case discounts allowed to payers of accounts are entered as sums expended, and discounts got on payment of accounts are placed among cash received, just as in the above form Cr. discounts go to Dr., and *vice versa*. Of such a book a concise specimen is subjoined:—

CASH BOOK.

1898.			Dr. £	s.	d.	Cr. £	s.	d.
June	2	To Balance, ...	91	12	0			
"	"	By two Oxen bought, ...				37	8	0
"	"	To Discount, ...	0	14	8			
"	4	By Grain Seed; Barley, £13 16*s.* 3*d.*; Essex Wheat, £1 18*s.* 9*d.*, . .				15	15	0
"	"	" Rye-grass, £1 10*s.*; Clover, £5 5*s.*				6	15	0
"	7	To Meal sold to Wm. Grant, . . .	37	14	0			
"	"	By Discount, ...				1	14	0
"	13	" 10 head of Cattle bought, at £6 16*s.* 8*d.* each, ...				68	6	8
"	"	To Discount, 5*s.* per head, . . .	2	10	0			
"	15	" 5 working Horses sold, £13 12*s.* each, ...	68	0	0			
"	"	By Discount, 4*s.* each, ...				1	0	0
"	"	To 1000 stones Hay at 1*s.* sold, .	50	0	0			
"	"	By Discount, ...				2	1	8
"	"	" Ditching, 5 men, 23 days, at 2*s.* 8*d.*, ...				15	6	8
"	24	To Summer grazing from A. Munro,	27	16	8			
"	"	By Discount, ...				0	6	8
"	30	" Balance, ...				129	13	8
			278	7	4	278	7	4
		Balance, Cash in hand, £129 13*s.* 8*d.*						

GEOMETRY.—CHAPTER III.

INDIRECT REASONING—EUCLID, BOOK I. PROP. VI.

Geometry accepts only of *reasoned* truth as worthy of being laid up in its archives as scientific fact. In that alone will it trust. It subjects every idea and suggestion brought before it to test and proof. Proof may either be direct or indirect. Hitherto all our reasoning has been direct. Here we have the first example given us by Euclid of indirect inference, and the earliest specimen of his application of that method of reasoning which logicians term the *argumentum ad absurdum.* This species of inference does not prove the statement made, but the absurdity of everything which contradicts that statement. It is often employed, as here, by geometers to demonstrate the converse—*i.e.* the direct opposite of a proposition already proved. Objection has been taken to the relevancy of such reasoning, but without substantial ground. Though in form it is neither so pleasing nor so elegant, it yields results which are simply and obviously accurate. The utmost that can be said against it is that it rather shows that a theorem *is* true than *why* it is so. Such reasoning is based upon this indisputable logical axiom: *Statements which are opposed to each other as contradictories cannot both—at one and the same time and in precisely similar conditions—be true.* One or other must be false. Hence, when the affirmation is true the negation is false, and when the negation is true the affirmation is false. "Yes" and "No" cannot be the proper answer to precisely the same question in precisely the same sense. Consistency of thinking requires that when we affirm or assent to a definite statement we must not at the same time deny it; while, of course, we must be prepared to deny every counter-affirmation which may be made to what we have accepted as true. But we must take care that the conflicting statements which engage our attention are really contradictory—*i.e.* distinctly opposed, and not merely contrary—*i.e.* only in part or degree opposed. It is only when we can disprove everything that is contradictory to any statement that, by such reasoning, we fully prove it. Beginners in geometry require to have their attention specially called to this point, because in the earlier portions of Euclid—*e.g.* I. 6, 14, 19, 25, 40, &c., the simple converse is shown to be true, and tyros might very readily conclude that all conversions are equally valid and equally simple. This, however, is by no means the case. The *converse* of a false proposition is not necessarily true. For instance, it is equally false that "all squares are equal" and that "no squares are equal;" while of the statement containing a proposition and its contradictory, "either all squares are equal or some squares are not equal," one must be true and the other false.

There is little difference in geometry between the impossible and the absurd. A statement which contains or implies the coexistence, at once, in the same thing or thought, of two qualities or ideas which mutually destroy each other, and which cannot be conceived by the mind as united together, is a proposition not impossible to be made, but impossible to be accepted by the intellect. The assertion that "a circle is a square" can be made in words, but it is impossible that it can be received as true by any one who understands the words used in it. Equally so would be the statement that "two right lines can inclose a space." Any course of reasoning which shows distinctly that the acceptance of any proposition under discussion leads to a conclusion necessitating a statement of this sort is called a *reductio ad impossibile*—bringing the mind to see that two ideas would require to be held in union which are unable to be thought of as so coexisting.

The Greek notion of analytical demonstration *ex absurdo* supposed, or for the time being accepted, the thing required (1) to be done, or (2) to be true; it then went over the demonstration point by point, showing at each the inconsistency (or, it might be, the consistency) of the hypothesis laid down, or the construction presented with the admitted truths of the axioms or previously demonstrated truths. It is necessary for the beginner to have this pointed out to him, otherwise the impression might be made on his mind that, because the requirements of an hypothesis having been (accepted as) complied with, it must necessarily be true; and that having *taken it for granted* there is an incongruity in afterwards rejecting it as untrue.

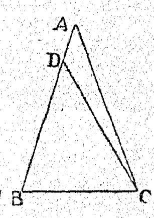
In the proposition to be brought before us, the converse of a part of the fifth proposition is to be proved. In that "the angles at the base of an isosceles triangle" were found to be equal. It is now proposed to convert this proposition into the form—two angles at the base of a triangle being equal, the triangle will be an isosceles one. Euclid supposes that statement to be denied. He knows that the axioms and the fourth proposition are invulnerable. They can neither be doubted nor denied. He grants, however, for the time being, that his statement may be disputed, and he agrees to accept of a proposition as (possibly) true which contradicts that statement. That there may be no mistake he places his theorem before the mind as follows :—

Proposition VI. Theorem.

If two angles of a triangle be equal to one another, the sides also which subtend (or are opposite to) the equal angles, shall be equal to one another.

The contradictory of this would be the theorem of the objector, viz.—If two angles of a triangle be equal to one another, the sides which subtend (or are opposite to) them are *un*equal to one another.

He proceeds to picture out his idea precisely, and thus brings it within the region of proof or disproof.



1. Let A B C be a triangle, having (if possible) the angle A B C equal to the angle A C B.
2. Then the side A C shall be equal to the side A B.
3. But if A C is *not* equal to A B, one of them must be greater than the other.
4. Let A B be the greater; then, from it, cut off (by I. 3) a part, D B, equal to A C the less, and join D C.

This *construction* being now, by presumption, accepted as correct, we have

5. The two triangles D B C, A C B, in which the side D B is equal to the side A C and the side B C is common to both; and, thus—
6. The two sides D B, B C are equal to the two sides A C, C B, each to each; and
7. The angle D B C is (by hypothesis) equal to the angle A C B.

This exactly reproduces the fact of the fourth proposition, giving us two triangles having two sides of the one equal to two sides of the other, each to each, and the angles contained by these sides equal to one another, in consequence of which we are entitled to conclude that

8. Therefore (1) the base D C is equal to the base A B; and (2) the triangle D B C is equal to the triangle A C B.

Now, we know from axiom 9 that "the whole is greater than its part," and the law of non-contradiction, as explained above, shows us that the same thing cannot be true and untrue at the same time and under similar conditions. We see, therefore, that the acceptance of the counter-proposition would require us to believe that D B C is equal to A C B,

9. The less to the greater, which is absurd.

Because the affirmation, by sufficient proof, of an assertion, and the denial by clear evidence of every possible contradictory of it, are equally conclusive as to the truth of a statement, we are now entitled to infer that

10. Therefore A B *is not* unequal to A C, *i.e.* it is equal to it.

11. Wherefore, if two angles of a triangle be equal to one another, the sides also which subtend, or are opposite to, the equal angles, shall be equal to one another.

A true *converse* arises when we can form one proposition by interchanging the subject and the predicate, and preserve the precise truth in the new statement thus made, and hence we deduce from the foregoing proposition this

Corollary.—Every equiangular triangle is also equilateral, the converse of the corollary of the preceding, *i.e.* the fifth proposition. See p. 140.

The converse theorem, drawn from the fifth proposition and proved in Proposition 6, is not the only one which might have been presented as involved in, and deducible from, the truth of Proposition 5. We might also have maintained the following:—If the angles formed by the base of a triangle and the sides produced are equal, the produced sides of that triangle are equal. It is easily seen that if the sides of the triangle were not equal they would not form an isosceles triangle, and if they did not do so the angles formed by the base and the produced sides could not be equal. It will be a good exercise of geometric ingenuity to figure this and extend the proof.

The student should notice that (1) in an isosceles triangle the base is that side which is not equal to the others; (2) in a triangle that is not isosceles any one of the three sides may be taken as the base, and then the angle opposite the base is the vertex.

Euclid has introduced this theorem here rather to complete the idea suggested by Proposition 5, than for any present need he had for it as a help in his progress. He does not use I. 6 till he has reached Book II., Proposition 4. It might have been demonstrated equally well after I. 18 or I. 26.

The next proposition is introduced only as a means of proving more readily the eighth, and it is never used again. The eighth proposition, however, which depends on this, is frequently referred to.

It seems very plain, one would say, even on a first thought, that there cannot be two isosceles triangles whose vertices shall stand outside of each other; but Euclid accepts of no appearances until they have been thoroughly brought before the mind and tested; and therefore he claims the assent of the judgment, after elaborate argument, for this his next (instrumental) theorem.

Proposition VII. Theorem.

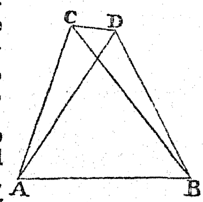
On the same base, and on the same side of it, there cannot be two triangles having their sides which are terminated at one extremity of the base equal to one another, and likewise those which are terminated at the other extremity equal to one another.

The following is another, and to some it may be a more intelligible, enunciation:—"On the same base, and on the same side of it, there cannot be two triangles which have their conterminous sides at both extremities of the base equal."

On considering this enunciation—"two triangles on the same base and on the same side of it"—and endeavouring to embody our conception of it in a figure, we shall find rising in our mind the three following possible methods of setting it before ourselves:—The vertex of the one must fall, if at all, I. outside of the other, II. within the other, or III. upon one side of the other. We may proceed to take these several cases up in their order:—

I. When the vertex of each triangle falls outside of the other.

1. If it be possible, on the same base A B, and on the same side of it, inscribe two triangles, A C B and A D B, which have their sides, C A, D A, terminated at one extremity, A, of the base, equal to one another, and likewise also their other sides, C B, D B, terminated at the other extremity, B, of the base, equal to one another.



The nearest possible approach to such a requirement may be supposed to be made in the annexed figure. Our two triangles being now, by hypothesis, drawn in accordance with the conditions, we proceed first of all to bring the matter into working order.

2. Join C D,

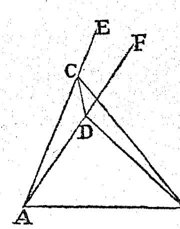
And thereby form the triangles C A D and C B D. This gives us the right to reason thus:—

3. Because A C is equal to A D—according to the hypothesis with which we started, and as a result of the truth demonstrated, I. 5—the angle A C D is equal to the angle A D C. But [inasmuch as the whole is greater than its part, we see that] the angle A C D is greater than the angle B C D, therefore the angle A D C is greater also than B C D, and the angle B D C is still greater than the angle B C D.

4. Once more; because, in the other triangle CBD, formed by joining C D, B C is equal to B D, the angle B D C is equal to the angle B C D (I. 5); yet the angle B D C has been demonstrated — in the previous paragraph 3 — to be greater than B C D, and

5. Hence B D C has been proved to be both equal to and greater than B C D, which is impossible. In this case, therefore, the assertion made in the theorem before us is justified.

II. When the two triangles are such that the vertex of the one falls within the other. This will yield a figure like the annexed.



1. Join C D, and produce the lines A C, A D, to E and F.

2. Because A C is equal to A D, A C D is an isosceles triangle; and the angles upon the other side of the base C D—viz. E C D and F D C, are equal to one another, and yet

3. The angle E C D is greater than the angle B C D, as is most obvious to the eye.

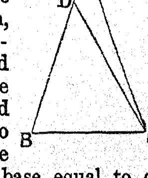
4. Wherefore the angle F D C (which equals E C D) is likewise greater than B C D.

5. Much more, then, is the angle B D C greater than B C D. Again, however,

6. Because B C is equal to B D, the angle B D C is (by I. 5) equal to the angle B C D.

7. But B D C has been proved to be also greater than B C D, which is impossible. And again the theorem is substantiated.

III. When the vertex falls on one or other of the sides, it is obvious at a glance that the conterminous lines are not equal to each other.



Having thus exhausted all the possible cases of the contradictory to the proposition, and shown, in each case, the absolute impossibility of their truth, we are justified in concluding, in the very terms of the enunciation, "that upon the same base, and on the same side of it, there *cannot* be two triangles having their sides which are terminated at one extremity of the base equal to one another, and likewise those which are terminated at the other extremity."

Of course, even a beginner can see that if we were allowed to let fall a perpendicular from the vertex of each of the triangles inscribed upon the same base, it would be easy to show that the angles at the base were only equal to one another when the same perpendicular bisected both triangles —*i.e.* when they were not two triangles, but geometrically identical, that is, one and the same.

In "A Syllabus of Plane Geometry" the following theorem is given to supply the place of Propositions 7 and 8:—"If two triangles have two angles of the one equal to two angles of the other, each to each, and have likewise the sides common to these angles equal, then the triangles are identically equal, and of the sides those are equal which are opposite to the equal angles."

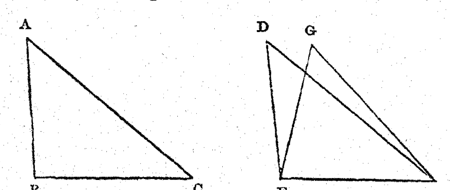
There are three cases of equality of triangles: (1) when they have one angle and the two sides by which it is formed equal each to each; (2) when they have three sides equal each to each; and (3) when they have one equal side each contained between two angles equal each to each. Proposition 4 dealt with the first, Proposition 8 deals with the second, and Proposition 26 with the third. In this way it happens that if of the six parts of a triangle any three—of which, in the case of angles, one must be an angle—be given equal each to each, the equality of the other parts is certain. It is thus that by the exact measurement of a single straight line and a sufficient number of angles, the indirect measurement of magnitudes and of the spaces they inclose becomes possible; as, for instance, in the trigonometrical survey of a country. It will easily be seen that propositions upon which so much depends must be of prime importance, and are worthy of the greatest possible attention.

Proposition VIII. Theorem.

If two triangles have two sides of the one equal to two sides of the other, each to each, and have likewise their bases equal, the angle which is contained by the two sides of the one shall be equal to the angle which is contained by the two sides, equal to them, of the other.

The elements of this proposition are: (1) two triangles which have (2) their three sides (*i.e.* two sides and a base) equal, each to each, and we have (3) to prove that the angle contained by the two (given) equal sides will be equal in both of the triangles.

1. Let A B C, D E F be two (such) triangles, having the two sides A B, A C, equal to the two sides D E, D F, each to



each, *i.e.* A B to D E and A C to D F, and also the base B C equal to the base E F.

2. Then the angle B A C shall be equal to the angle E D F.

3. For if, by superposition, the triangle A B C is applied to D E F, so that the point B is on E, and the straight line B C on E F, then the point C shall coincide with the point F, because B C is equal to E F.

4. Now, as B C coincides with E F, B A and A C shall coincide with E D and D F.

5. For, if they do not, but take a different position —as E G, F G—then, on the same base and on the same side of it, there would be (on this supposition) two triangles having their sides which are terminated at one extremity of the base equal to one another, and likewise their sides which are terminated at the other extremity; but this we have seen in Proposition 7 is impossible. Therefore,

6. Since the base B C coincides with the base E F, the sides B A, A C, *must* coincide with the sides E D, D F.

7. Therefore, the angle B A C coincides with the angle E D F, and (as axiom 8 warrants) is equal to it.

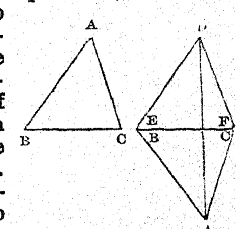
In point of fact, this theorem shows us far more—viz. that the two triangles are in every respect alike. This is very obvious, for the three sides being given equal, each to each, fixes the condition of the angles possible in each triangle. But Euclid never carries his conclusions beyond the proof his premises afford. His reason for laying down for himself—and those who learn geometry through his Elements—the rule, that nothing is ever to be supposed to be done the manner of doing which has not been previously taught and tested as right and true, was, as Playfair says, "to guard against the introduction of impossible hypotheses, or the taking for granted that a thing may exist which in fact implies a contradiction." This proposition is therefore a specimen of the *argumentum ad impossibile*, an exposure of the inconsistency of thought which may result from resting content with unexamined and unattested negations.

Dr. Olynthus Gregory, professor of mathematics in the Royal Military Academy, used to object to the word "contained" as employed in this theorem, that it implied "space" instead of "boundary," and thought that we ought to use, or at least understand, the word as meaning "formed." "Angles," he said, "do not *bound*, *i.e.* contain, space, and angles may be *equal* without an entire coincidence of their bounding lines." Hence, also, he objects to the relevancy, as an argument, of the use of axiom 8, that "angles do not *fill* the same space."

A very simple method of proving this *eighth* proposition may be suggested.

1. Let the two triangles be described as before, having the two sides A B, A C equal to the two D E, D F, if the angle at A were greater than that at D, then B C would be greater than E F, but they are equal, therefore the angle at A cannot be greater than that at D. Nor can the angle at A be less than the angle at D, for in that case B C would be less than E F, but they are equal. Since the angle at A is neither greater nor less than the angle at D, it must be equal to it. If the angle at A equals the angle at D, we have two triangles having two sides of the one and a contained angle equal to two sides and a contained angle of the other, each to each, and so fulfilling the requirements of Proposition 4. Hence they are equal in all respects—sides, angles, and areas.

The late Robert Potts, M.A., Cambridge, proposed the following direct demonstration of Proposition 8, viz.—Let the triangles A B C, D E F be so placed that the base B C may coincide with the base E F, and the vertices A and D may be on opposite sides of E F. Join A D (if necessary). Then E A D is an isosceles triangle, and the angle E A D is equal to the angle E D A. Again, because F D A is an isosceles triangle, F D A is equal to F A D. As then—if equals are added to equals the wholes are equals—the two angles E D A and F D A (that is, the whole angle E D F) are equal to E A D, F A D, that is, the whole angle E A F; that is, E A F (which is also A B C) is equal to E D F.



BOTANY.—CHAPTER III.

ROOTS—THEIR FUNCTIONS, FORMS, VARIETIES, USES, AND PRODUCTS.

Having brought under the student's notice the simple organic tissues of which vegetables are composed, we ought now to be ready to proceed to the study of *Organography*, or the examination of the various *compound organs* of which plants consist, and which they require for the due performance of their functions. The principal of these are the *root*, *stem*, *buds*, *leaves*, *flowers*, *fruit*, and *seed*. These differing parts of the plant-body are all in organic connection with each other, although the whole of them are not always present even in perfect plants. There are few plants, however, in which the greater portion are not, in some shape or other, to be found when we learn how to identify them. The root, stem, and leaves are the organs of nutrition, and flower, fruit, and seed are the reproductive parts of a plant.

The root is that part of a plant by which it is attached to the soil, or the substance on which it vegetates, and is the principal organ for the supply of nourishment. It is usually the lower extremity of the plant, by means of which it is fixed to the ground or place on which it grows, preventing its being torn up by animals or upset by the wind. Its use is the absorption of nutritious matter for the plant's support, and the giving out a portion of what is useless or noxious to it.

The bodies of all the higher orders of plants consist of specific organs performing special functions. It is the duty of those engaged in botanical research to examine all the parts of plants, however various their manifestations, so as to obtain a knowledge of their morphology, and of the gradual transition made by one organ into another. The *axis* and its *appendages* compose a plant. The ascending axis, rising above ground with its appendages, becomes the visible part of the plant; the descending axis, with its appendages, passing into the ground, becomes the root or nourishment seeker and sucker. Of these two relative type-parts of plants, all the others are developments. Roots vary (1) in form and (2) in function. A root, in popular language, means any part of a plant which is formed underground; but in the technical morphology of vegetables it has acquired a more distinct signification. Roots are not found in thallophytes—*i.e.* seaweeds, funguses and lichens; or bryophytes—*i.e.* liverworts and mosses; but, of all such plants as possess a fibro-vascular structure, roots appear to be a necessary part. In these the pileorhiza, root-cap, or dermatogenous growing point, forms the meeting-place of that mass of protomeristem from which the permanent tissues of the plant are formed. That part of the plant whose function it is to seek, find, and, if requisite, store the means of growth, whatever its form, is the root; while that part which is to develop into fresh form, new life, and reproductive germination—floral or otherwise—is the stem. Function, not place, therefore determines the character of the root. It is important to notice this difference between the popular and the technical use of the word root—as many plants, like tulips, onions, snowdrops, lilies, potatoes, &c., have portions underground which, though often called so, are really *not* roots. Yet a root, it may be observed, may be dry and woody, or soft and juicy, according to the nature assigned to a plant, and may vary in size from a hairlike fibril to the thickness of an athlete's arm. The keeping of this typical definition in our minds will enable us to know the true structural function of a root, and while we need not pedantically refuse to employ common phraseology, it may be just as well to understand the precise nature of the things referred to. Thus we may think with the philosopher of radicle and plumule, and yet talk with the common people of root and stem.

At or about the same time that the ascending axis or stem of a plant seeks to rise toward the light, from the seed which has been placed within the earth, the opposite extremity of the seed or bud buries itself in the earth, and becomes a root, with a tendency downwards so powerful, that almost nothing can overcome it. Correctly speaking, that only can be considered a root which has such an origin; for those roots which are emitted by the stems of plants, as in the banyan tree, are in reality the roots of the buds above them.

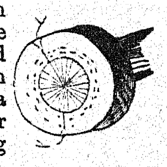
Independently of its origin, the root is distinguished by several other unvarying characters. Its ramifications occur irregularly, and not with a symmetrical arrangement. The rootlets strike out, as it were, capriciously and amorphously. They do not, like branches, proceed from certain fixed bud-like points, but are produced from any part as need is. Thus, roots have no scales, leaves, or other accessories, nor do they even indicate upon their surface, by the remaining scars, any traces of such things as these having existed. Roots are always, in exogenous plants, solid, and have no central column or thread of pith. All underground ramifications having scales on them are really stems, by whatever names they have been called. The only accessories which roots have ever been found to have are little floating bladders, such as are found in the bladder-wort (fig. 1). It is by these that the plant is supported on the surface of the water during the expansion of its fine yellow flowers. They are filled with water till this is necessary, with air while this is going on, and, when it is finished, they are replenished with water again.

Fig. 1.

Almost all plants—excepting only some of the simplest, which absorb their nourishment through pores placed all over them, and have no distinction of stem, or root, or leaves—possess roots. Although it has been said, and is generally true, that the root is a means of fixing plants to other objects, there are some which, as in the preceding figure, hanging down into the water, are unattached. The same is the case with several of the seaweeds. Some are attached to other plants, from which they abstract nourishment, doing them thus a great deal of harm, as the mistletoe, and many of those plants, in hot climates, belonging to the order of Orchideæ. Of these latter some have long roots hanging down from the branches of the trees on which they are fixed, and derive their nourishment from the warm moist atmosphere, highly loaded with vapour, in which they flourish. The common ivy might be taken as an example of a parasite, for although it has always a root in the ground, it also sets its radicles or little rootlets into the tree to which it clings, so as ultimately to injure it, causing it, through exhaustion of sap, to wither and die.

Roots present two parts, sufficiently distinct to be discriminated. These are (1) the descending stem, and (2) the radicles. The *descending stem* or *caudex* is the part which usually passes far down into the earth—with whose ordinary elongated form we are all familiar, in the carrot (Plate II. fig. 3, *Daucus*), the radish (*Raphanus*), and the firm woody roots of trees. It is of a fibrous texture, like the stem, presenting long spirally twisted filaments, on which its strength and toughness depend, intermingled with a great many vessels, and exhibiting also, like the stem, medullary rays, radiating from the centre. The bark is thicker than on the ascending stem, and is frequently soft and fleshy. The red part of the carrot, as shown in fig. 2, is the bark of the root, and has a kind of cuticle or skin investing its outer surface, and forming a sort of protecting shield to the young extremity of the root.

Fig. 2.



In woody plants, the stem and the root are very similar in texture, and interchange with one another. Thus an ash-tree may be seen growing on the rotten stump of an old pollard willow, into which its seed has fallen and taken root. Its roots having penetrated through the rotten old stump, until they have arrived at the earth, fix themselves into it. Gradually the old willow, rotting away, falls to pieces. Then the roots of the ash, left exposed to the air, become coated with a green bark, like the rest of the stem, instead of the brown covering which hitherto invested them while holding the station of roots. It is not uncommon to see roots reaching the surface and becoming *suckers*, rising into young stems. This often happens in the case of the poplar and the plum. The converse also is occasionally seen. Branches send down pendent shoots towards the earth, which by and by fasten themselves into it, and become changed into new stems.

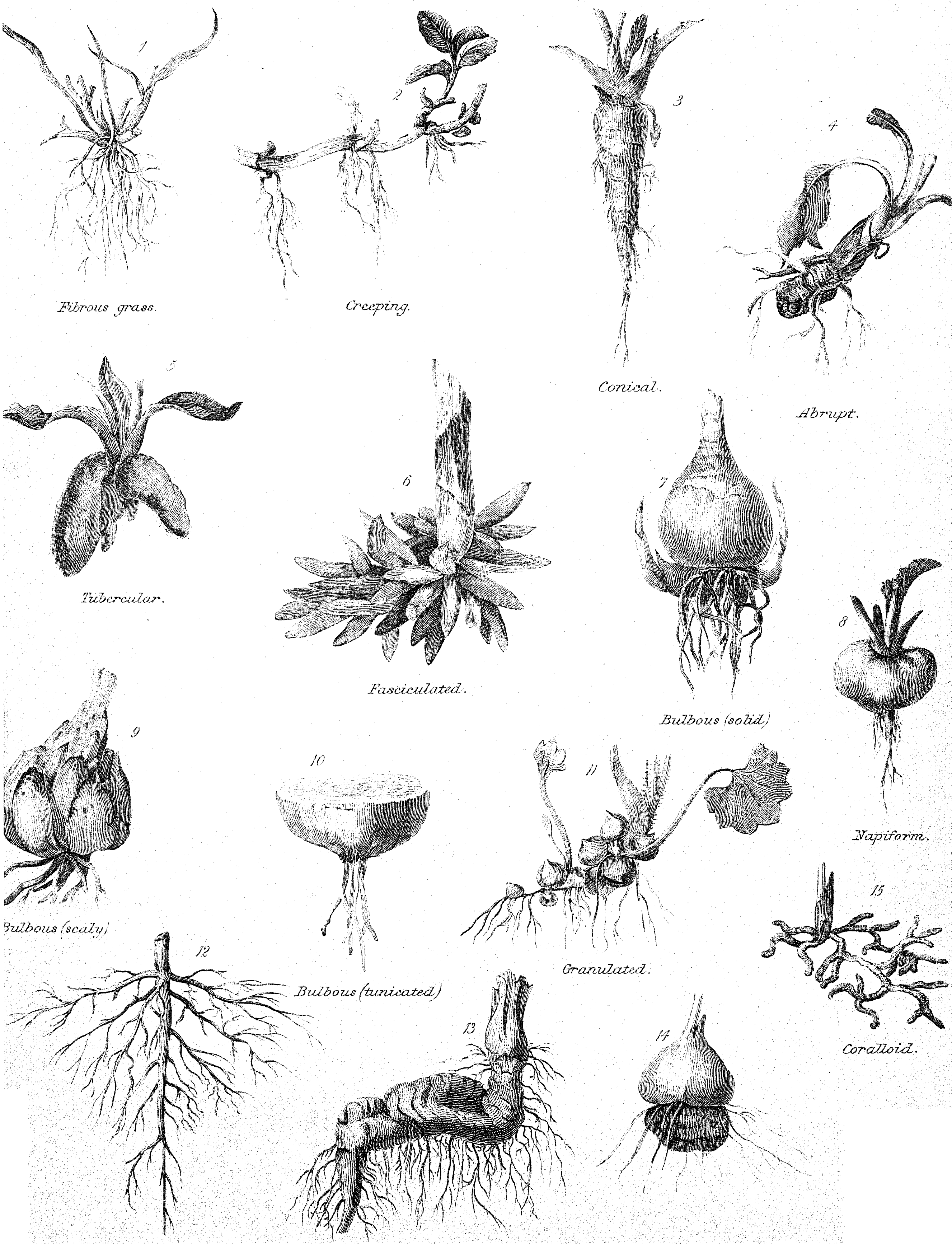
The banyan tree (*Ficus Indicus*, fig. 3), in this manner, often spreads over a great surface, and, forming an extensive arcade of immense size, endures for many ages. A specimen has been described which covered a surface of nearly two acres, with 350 or 360 stems. The following beautiful lines, from Southey's "Curse of Kehama," form a fine companion picture in words to the illustration given opposite, in which many roots are seen hanging down on their way to the earth, so that they may fasten themselves therein and become additional stems.

"It was a goodly sight to see
That venerable tree;
For, o'er the lawn irregularly spread,
Fifty straight columns propt its lofty head;
And many a long-depending shoot,
Seeking to strike its root,
Straight, like a plummet, grew towards the ground.
Some on the lower boughs, which crossed their way,
Fixing their fibres round and round,
With many a ring and wild contortion wound;
Some, to the passing winds, at times, with sway
Of gentle motion swung;

BOTANY.

ROOTS.

PLATE II.

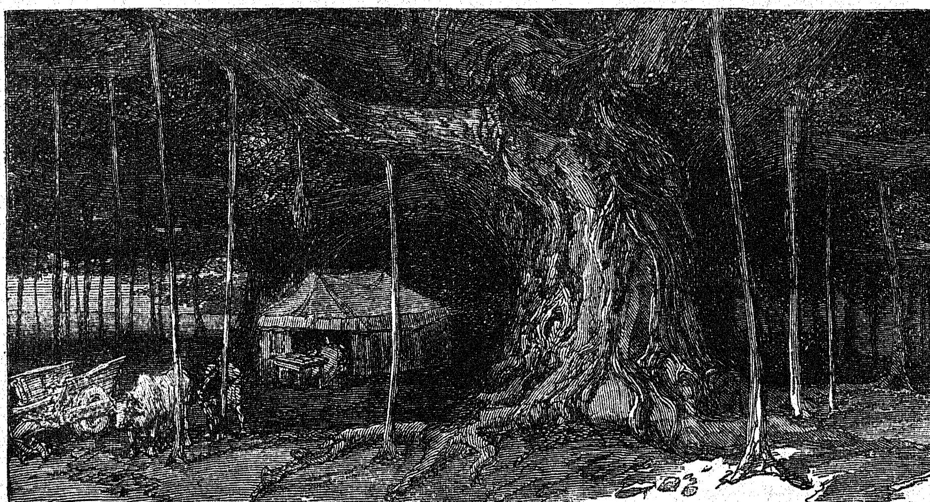


Others of younger growth, unmoved, were hung
Like stone-drops from the cavern's fretted height;
Beneath was smooth and fair to sight,
Nor weeds nor briars deformed the natural floor;
And, through the leafy cope which bowered it o'er,
Came gleams of chequered light.
So like a temple did it seem, that there
A pious heart's first impulse would be prayer."

The middle or fibrous part of the root, instead of becoming elongated, is sometimes much enlarged, swollen, or rounded, and fleshy—as in the turnip (*Brassica rapa*, fig. 8, Plate II.). This globose or oblong part is covered with a bark, which peels off. It may be succulent and cellular, tough and fibrous, or firm and woody, but it always contains a large proportion of vessels running through its roundish form.

The *radicles* or little fibrils, which hang from what are commonly called the roots, are the essential parts, the real roots. They are always found in vegetables, because it is through them that nourishment is supplied to the plant. If a root be cut across, these fibrils are seen penetrating the

Fig 3.



Banyan Tree (*Ficus Indicus*).

bark, and reaching the central part, as in fig. 2. At the end of each fibril of the root there is an enlargement full of pores, like a little sponge, through which the fluids it absorbs pass into it. The necessity for the absorbing power of these spongioles is proved by a simple experiment. Take a radish (fig. 4), bend it, and put it in water, so that the bent part may be in the water, but the radicles out of it; no absorption will then take place, and the plant will fade away. Having been satisfied of this, let the experimenter now put the end of the root in, so that the radicles with their spongioles have access to the water; the plant will very soon revive and begin to grow.

These little fibres of the root have a wonderful power of insinuating themselves into every place — were it only a crevice — from which any nourishment can be extracted. Plants of many kinds, and even trees, may be seen living upon apparently bare rocks, their roots inserted into the clefts and fissures, where one would think that nothing could be absorbed except the drops of rain which the shade had prevented from being evaporated. The mistletoe, a parasite

Fig. 4.

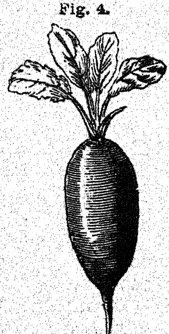


Fig. 5.

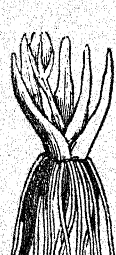
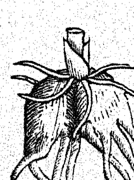


Fig. 6.



which is often found upon old apple trees, never takes root in the ground itself, but preys upon the juices which the apple tree is appropriating to itself, striking its radicles through the bark to its inner surface, where (as was explained in chap. ii. p. 145) the *proper vessels* or receptacles of secretion are most numerous, running in the inner layer, for the purpose of depositing the materials for the new outer layer of the wood.

The upper part of the root is the *crown*, *neck*, or *life-knot*, where the root and stem join, and which, perhaps, can scarcely with propriety be said to belong to either. From this life-knot, in those perennial plants which die down to the ground in winter, the new stem shoots up again in the succeeding spring. When the root has no *tail* (caudex), the fibrils spring from the neck or crown (fig. 4), where it appears as a flattened part with a somewhat projecting rim just below the bulb.

This general idea of the *root* as the organ which provides, by absorption, for the nourishment of plants, being given, it will be proper now to take a more detailed look at the various *forms* which roots assume. This is all the more important because these are sometimes referred to in describing the difference of species of the same genus. In speaking of them we shall refer to those parts which are found below the ground, without referring to the debatable question of stem and root, where they seem sometimes to encroach on one another's territory—the root rising above the ground, or the stem descending below it.

The *fibrous* root may be either (1) simple (fig. 5), as in many monocotyledonous plants; (2) *branched*, as in the grasses (fig. 1, Plate II.); (3) *creeping* (fig. 2, Plate II.), as that of the common strawberry or the club-rush, which forms a great portion of the fibrous part of peat. This form of root may be fleshy, like that of the cyclamen, the dahlia, and the common pig-nut: as such it puts on several different forms. (4) *Fusiform* or tapering, like the carrots and radish (fig. 3, Plate II.); (5) *abrupt*, as if the end had been bitten off, as in the scabious roots of the teasel and the devil's bit (fig. 4, Plate II.); (6) *tuberous*, like that of the potato. The tubers, however, are rather an addition to the root than the root itself; for in the spring, when potatoes, lying in the cellar, begin to grow, long thin *true* roots are seen striking out from what are called "the eyes" in the tuber. All the plants of the Orchis tribe have tuberous roots, and are frequently divided in such a peculiar manner as to give one of the chief characters to the species. Some of them have the *tubers* in pairs, hence called *didymous* or twin (fig. 5,

Plate II.) Others have them divided in pairs, and each of them divided into four or five fingers, hence deriving the name of *palmate* (fig. 6). Where the fleshy mass is pear-shaped, rising from the life-knot, it gets the name of a *bulb*, as in the crocus, hyacinth, and onion. The bulb may be *solid*, as that of the crocus (fig. 14, Plate II.), having the green bud of the leaves rising from it and the flattened disc below it, from which the roots hang down, covered with a thin brown cuticle, which peels off in narrow strips. This root, whose solidity is shown in the cross section below (fig. 7), is some-

Fig. 7.

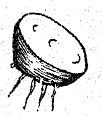


Fig. 8.

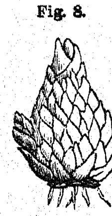
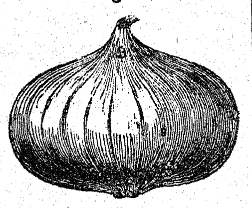


Fig. 9.



times called a *cormus*. Fig. 8 is a *scaly* bulb, also solid, but distinguished by its covering of scales. These are *imbricated* or laid over one another, as indeed scales must always be. The onion is a bulb, too (fig. 9), but it approaches more obviously to a stem in its structure than the other bulbs do; for, if it be cut across, it is seen to consist of many layers wrapped round one or more centres (fig. 10, Plate II.) Sometimes the tubers are numerous and small, and when very small, like peas, connected by stringy fibres, the root is said to be *granulated*, as in the saxifrage (fig. 11, Plate II.) These different bulbs and tubers, however varying in their form, are all intended for the same purpose—to serve as storehouses of nourishment during the winter, from which the new stem and leaves may shoot up in the spring. Every one who cultivates hyacinths or dahlias takes them up in the end of autumn to be laid past and protected from the frost. They are planted again, so soon as *that* enemy has disappeared, in the *spring*. The hardier bulbs, as those of crocuses and lilies, are able to withstand the cold, and are therefore allowed to remain in the ground.

It is curious, however, that plants of this kind increase in a twofold way. Besides their flowers and seed, they have buds springing from their solid roots. The tuber of the potato presents *eyes*, from each of which, when influenced by heat and moisture, a new bud may break out and give origin to a root and a stem. It is found in many cases more advantageous to propagate the plant in this way than from the seed —the resulting young ones being much larger and stronger. Thus no one now thinks of sowing these from the seed in its globular purplish fruit called potato plums, unless in the expectation of perhaps acquiring some new variety. For economy's sake, a single potato is not planted whole, but is cut into several pieces first; and, it must be plain, from what has been said, that the cutter must take care to preserve one *eye* at least in each piece. Solid bulbs, like the crocus, propagate also in this way, but, having no eyes over their surface, the new one grows from the top of the old (see fig. 14, Plate II.), *i.e.* the life-knot. In this way it is that those beautiful patches of crocuses are obtained, in which the various coloured flowers blow as thick as they can stand, having been multiplying by the roots for many years, with, of course, yearly additions from the seed which had been allowed to ripen. In the case of the scaly bulb, the new one grows from the side of the old one, separating some of the scales, and emerging between them, as in the large white lily (*Candidum*). In some plants which grow from scaly or coated bulbs, we occasionally find the buds, which are placed in the angles between the stems and branches, modified in a curious fashion. Instead of expanding into branches and leaves in the ordinary way, the rudimentary coats of which they consist enlarge, becoming deposits of nourishment, from which growth may afterwards be supported, but in the meantime continuing in a condensed or undeveloped form. These bulbs are familiar as growing upon the orange lily (*Lilium bulbiferum*), and even among heads of flowers, as on a variety of the common onion.

It can scarcely be necessary to say further, that all the substance of a root which does not consist merely of the radicles, their spongioles, and the vessels belonging to them, must be intended either to give the plant a firm hold upon the earth, so as to resist the vicissitudes of the seasons; or to serve for a storehouse of nourishment, where that which was drawn from the earth is laid up, to be ready to furnish supplies for the growth of the coming spring, before its fresh roots have struck out, so as to attract any fresh nutriment.

Generally speaking, every part of a root has the power of throwing out new rootlets or fibres; so that, by taking a cutting, or portion of a root, and transplanting it, new roots will strike out, and those which exist already will grow bigger. From these a stem will rise above ground, and thus a new plant will be obtained. Many stems even have this power, sending out roots from the buds which would have become branches had they remained in the air. In every garden the ranks of the gooseberry and currant bushes are increased in this way—a slender shoot being cut from off a bush of a good kind, and set in the ground, where it speedily takes root and begins to shoot out leaves and twigs.

Besides drawing nourishment from the soil, it has been ascertained that roots have the duty of excreting, or sending off, part of the circulating fluid which is not required, or is unsuitable for their growth. If a young growing plant be placed in a glass of water, this will be found in a few days to contain matter excreted from the roots, differing in different kinds of plants. It has also been found, by careful experiment, that a plant may be induced to take up a noxious substance dissolved in the water in which it is growing; and that it will get quit of this again from its roots, when they have been washed and placed in clean water. This discovery explains the necessity for, and the advantages of, the rotation of crops, the action of what are called weeds, the utility of changing the earth of plants growing in pots, and various other phenomena of plant-life. Rose trees, for instance, are the better of being moved after having been in the same ground for a few years.

Besides the functions of absorption and excretion, which are perhaps their main uses in the vegetable economy, roots subserve several other important purposes in plant-life. By means of the root, the plant maintains its place in the earth. It is not only, therefore, because an increase of the power of absorbing nourishment demands the outspread of the root that its radicles and fibrillæ extend and ramify. These act as holdfasts in the earth, so that the stem may be retained in a firm and upright position. The roots of plants act as an accommodation of the temperature of the plant to its condition—keeping it in winter above, and in summer below, the temperature of the surrounding atmosphere. It is easily seen that the roots by their absorption of fluids at some distance below the earth's surface gain nourishment which has not been much affected by the changes in the outer air. It is from this circumstance, too, that trees are enabled to collect from the earth, which is so much cooler than the atmosphere in tropical climates, those delicious cooling juices, so delicately flavoured in their course of distillation through the plant, which furnish such refreshing and various moisture to appease the thirst of the dwellers in those hot countries where thirst is so common and commanding. Many roots, also, contain secretions either peculiar to themselves, or more abundantly treasured up therein than in other portions of the plant. These often become valuable in the arts, as yielding dyes like madder (*Rubia tinctorum*), or perfumes, like orris root (*Iris Germanica*), and in medicine, as gentian and elecampane (*Inula Helenium*). Not only do roots grip the soil and preserve to the plant a local habitation, but they are the feeders of the growth of the living structure they support. By their agency the curious chemistry of plant-life is made possible, so that the moisture and matter of the earth undergo transformation into the products of stem, leaf, flower, and seed-vessel, or are so acted upon in the laboratory of the plant's interior, that it becomes the treasure-house of the artist's pigments, the chemist's elements, and the physician's healing medicaments.

Roots are distinguished into annual, biennial, and perennial. *Annual* roots grow up, and produce leaves, flowers, and fruit all in one season, and then wither away and perish.

The barley and the poppy are examples. *Biennial* roots produce herbage the first season, but no flowers; the second summer they shoot out stems and flowers, run to seed, and die away, as in the case of the carrot, the cabbage, the fox-glove, &c. *Perennial* plants are those which live many successive seasons. Some of them are herbaceous, sending up stems and leaves, which flourish and fade down to the ground in one season, as the asparagus does; while the root remains, and sends up a new crop with the returning spring. Others remain entirely above ground, and are called shrubs or trees. In botanical books, certain signs are used for these modifications—⊙ signifying annual; ♂, biennial; ♃, perennial. Plants are sometimes changed from annual to biennial and perennial, by change of climate and cultivation.

It is important to know that the reason of the drooping and withering of plants, when shifted from one part of the garden to another, is that the spongioles of the roots frequently get broken off during the operation. A good ball of soil ought always to be kept about them, and then transplanting is possible with little check of growth and no injury. It may be as well also to remark here, that it is improper to perform transplantation except when the juices of the plant have retired and it is dry, as during winter; and then the new radicles, which shoot out again in spring, will act just as if the plant had been left alone.

We will now condense into the smallest bulk an epitome of the preceding pages, so that the information presented may be compactly brought before the mind, readily referred to, and rapidly run over when it is desirable to refresh the memory.

The root is the organ which secretes nourishment for the plant (generally) from the earth. Aerial and parasitic roots are, of course, peculiar modifications.

The special uses of the root are—(1) to fix the plant, (2) to nourish it, (3) to collect useful materials, (4) to eject innutritious substances.

The parts of the root are—(1) the neck or crown, (2) the caudex or descending part, and (3) the spongioles.

Roots develop (1) endogenously, (2) without acropital leaves, and (3) from a growing point or root-cap.

In this manner roots are (1) morphologically known; (2) popularly they are regarded as the parts of a plant formed and found underground. This is the sense the word bears when we speak of *root-crops.*

Morphologically, roots are only of two varieties, (1) primary or true, (2) secondary or adventitious. The former is produced by the direct descending growth of the radicle of the embryo; the latter does not proceed from a definite point, but is accidental in origin.

The *true* root is usually called a *tap* root (fig. 12, Plate II.) Monocotyledonous (single-lobed) and acotyledonous (lobeless) plants, aerial and parasitic roots, roots modified from stems, slips, cuttings, &c., are regarded as *adventitious*, and are most frequently *fibrous.* When roots are storehouses of matter they are called *tuberous* or *tubercular*.

Plate II. gives examples of the most important varieties of roots, which are as follows:—Fibrous (fig. 1); creeping (fig. 2); conical (fig. 3); abrupt (fig. 4); tubercular (fig. 5); fasciculated (fig. 6); bulbous (solid) (fig. 7); napiform (fig. 8); bulbous (scaly) (fig. 9); bulbous (tunicated) (fig. 10); granulated (fig. 11); tap root (fig. 12); rhizome (fig. 13); corm (fig. 14); coralloid (fig. 15).

THE GERMAN LANGUAGE.—CHAPTER IV.

GENDER.

Sex is a distinction between living beings; *gender*, a distinction between words. German regards nouns as distinguishable into three genders—masculine, feminine, and neuter—indicative respectively of the male, the female, and the absence of sex.

In names of persons, and of those animals in which it is requisite to indicate the natural distinction of sex, grammatical gender coincides with natural sex; as der Mann, die Frau; der Löwe, the lion, die Löwin, the lioness.

To this rule das Weib, the woman, is an exception, being neuter, as are also some diminutives and derivatives which take their gender from their last component part; as das Mädchen, the girl, das Frauenzimmer, the woman.

The gender of German as well as of French nouns has been settled rather by custom than by wisely founded principle. Men do not always look on things with the clear and cold light of reason. Their thoughts are quickened by their imagination and associations, and they thus think of things as bringing bane or blessing, sorrow or joy, and bestow upon them an imaginary sex in accordance therewith. Thus in the sex given to inanimate objects we may look for indications of national temperament, and the student must be prepared for the strangest contradictions; in German, the moon, war, victory, and death are masculine, and the sun and love feminine; while in French the former are feminine and the latter masculine.

It is impossible to teach well by mere rule the proper gender of German nouns. The following remarks will help somewhat, but much reading and close observation are required to attain the mastery of this difficult subject; it greatly aids the memory if before each noun the student will think of and employ the proper gender of the definite article.

Gender is to a certain extent known by the *meaning* and by the *form* of a noun.

I. By their *meaning* the following classes of nouns are known to be *masculine:*—

Names of males and offices generally held by men, except diminutives in chen and lein, which are all neuter; as

der Bäcker,	the baker.	der Schmied,	the smith.
der Kaufmann,	the merchant.	der Schneider,	the tailor.
der Metzger,	the butcher.	der Schuster,	the shoemaker.
der Müller,	the miller.	der Sohn,	the son.

der Stier, the bull.

The names of the seasons, months, and days (except das Jahr, the year); as der Winter, the winter; der Mai, May; der Sonntag, Sunday.

The names of stones, rocks, mountains; as der Marmor, marble; der Kaukasus, the Caucasus.

In the same way the following classes of nouns are known to be *feminine:*—

Names of females and of offices peculiar to women; as die Tochter, the daughter; die Magd, the maid-servant; die Ziege, the she-goat.

Names of fruits, trees, and flowers ending in e; as

die Buche,	the beech.	die Rose,	the rose.
die Eiche,	the oak-tree.	die Tulpe,	the tulip.
die Lilie,	the lily.	die Ulme,	the elm.

The following classes of noun are usually of the *neuter* gender:—

Names of materials and metals (except der Stahl, steel); as

das Holz,	wood.	das Glas,	glass.
das Eisen,	iron.	das Gold,	gold.

Names of countries and places, to which, however, the article is not prefixed unless an adjective precedes the noun; as Petersburg, Petersburg; Preußen, Prussia. But we say die Türkei, Turkey; die Schweiz, Switzerland.

Other parts of speech used as nouns; as das Warum, the why; das Trinken, drinking; das Nützliche, the useful.

Names of species of animals for the different sexes of which there exist distinct names; as das Huhn, the fowl (der Hahn, the cock, die Henne, the hen).

All diminutives in chen and lein; as

das Stühlchen, the little chair.	das Bächlein, the little brook.
das Söhnchen, the little son.	das Fräulein, the young lady.

This rule includes a large number of nouns, and is therefore of much importance, as in the German language diminutives are very frequently used. In forming them the Germans add the syllable chen or lein to primitive words. If the primitive word ends in e or en, this termination is omitted in forming the diminutive, and almost all diminutives change a, o, u into ä, ö, ü; as

die Taube, the pigeon; das Täubchen, the little pigeon.
der Garten, the garden; das Gärtchen, the small garden.

II. By the *form* of the word grammarians require us to regard as *masculine*—

By far the greater number of primitive words.

Most nouns ending in all, el, er, en, lm, and ing; as

der Ball,	the ball.	der Degen,	the sword.
der Stall,	the stable.	der Ofen,	the stove.
der Sperling,	the sparrow.		

Nouns derived from the imperfect indicative of strong verbs; as der Trunk, the drink, from trinken, to drink; der Ritt, the ride, from reiten, to ride (on horseback).

In the same way grammarians require us to regard as *feminine*—

Derivative nouns ending in ath, ei, heit, keit, schaft, ung, in, and some in niß; as

die Heirath,	marriage.	die Freundschaft,	friendship.
die Druckerei,	the printing-office.	die Kinderei,	childishness.
		die Hoffnung,	hope.
die Gesundheit,	health.	die Königin,	the queen.
die Sauberkeit,	neatness.	die Kenntniß,	knowledge.

III. Nouns ending in sal, sel, and thum are usually neuter; as das Schicksal, fate; das Räthsel, the riddle; das Alterthum, antiquity.

The same may be said of most collective nouns beginning with ge; as das Gebiet, the territory.

Compound nouns retain the gender of their last component noun; as der Hausvater, the father (of a family); das Vaterhaus, the (family) home.

Several nouns, when used in a different gender, have a different meaning:—

der Band,	the volume of a book.	das Band,	the band.
der Bund,	the alliance.	das Bund,	the bundle.
der Bauer,	the peasant.	das Bauer,	the cage.
der Chor,	the chorus.	das Chor,	the choir.
die Erkenntniss,	the knowledge.	das Erkenntniss,	the sentence.
der Erbe,	the heir.	das Erbe,	the inheritance.
der Gehalt,	the contents.	das Gehalt,	the salary.
der Gift,	the saliva.	das Gift,	the poison.
die Gift,	the dowry.		
der Heide,	the pagan.	die Heide,	the heath.
der Hut,	the hat.	die Hut,	the care.
der Kunde,	the customer.	die Kunde,	the knowledge.
der Leiter,	the conductor, guide.	die Leiter,	the ladder.
der Mangel,	the want.	die Mangel,	the mangle.
der Lohn,	the reward.	das Lohn,	the wages.
der Schild,	the shield.	das Schild,	the sign-board.
der See,	the lake.	die See,	the sea.
der Thor,	the fool.	das Thor,	the gate.
der Theil,	the part.	das Theil,	the share.
der Verdienst,	the gain.	das Verdienst,	the merit.

EXERCISE.

The following sentences are given in German and Roman characters, and have the English placed under them. This will help just now not merely in recalling the correspondence of the letters, but also in the writing out of the exercise; for of course these sentences should be carefully read and written out:—

Das Ei hat eine Schale.
Das Ei hat eine Schale.
The egg has a shell.

Der Hut schützt den Kopf.
Der Hut schützt den Kopf.
The hat protects the head.

Auf der Kirche ist ein Kreuz.
Auf der Kirche ist ein Kreuz.
Over the church there is a cross.

Das Dach schützt das Haus.
Das Dach schützt das Haus.
The roof protects the house.

Wer braucht eine Peitsche?
Wer braucht eine Peitsche?
Who needs a whip?

In dem Garten ist eine Laube.
In dem Garten ist eine Laube.
In the garden there is an arbour.

Was schneidet man mit der Säge?
Was schneidet man mit der Säge?
What do we cut with saws?

Welche Bäume haben kein Laub?
Welche Bäume haben kein Laub?
Which trees have no leaves?

Wozu braucht man den Besen?
Wozu braucht man den Besen?
For what does one need the besom?

Der Töpfer macht den Topf.
Der Töpfer macht den Topf.
The potter makes the pot.

Wozu braucht man den Wagen?
Wozu braucht man den Wagen?
For what does one need the carriage?

Write out in three separate columns (according to gender) (1) the nominative singular of all the masculine, feminine, and neuter nouns in the above sentences; (2) place the proper definite article before each noun; (3) write after each noun the figures 1, 2, or 3, to show the declension to which it belongs; then (4) write the nominative plural opposite each noun.

CHAPTER V.

ADJECTIVES—THEIR NATURE, DECLENSION, AND COMPARISON.

Adjectives are used to qualify nouns. As in English, a great number of participles are used as adjectives.

Adjectives may be either (1) immediately joined to a substantive, as the large house; or (2) mediately by the verbs sein, to be, or werden, to become, &c., as the house is large. In the former case they stand before the noun, and are called *attributive;* in the latter the verb stands between them and the noun, and they are called *predicative.*

An attributive adjective is *variable, i.e.* it changes its termination according to the gender, number, and case of the noun it qualifies; as ein guter Mann, a good man; eine gute Frau, a good woman; ein gutes Kind, a good child.

A predicative adjective is *invariable;* as der Mann ist gut, the man is good; die Frau ist gut, the woman is good; das Kind ist gut, the child is good; die Aepfel sind gut, the apples are good; sie schnitten es kurz, they cut it short.

Adjectives are also invariable when they stand in *apposition;* as der Knabe, klug und artig, the boy, prudent and polite (for this is an elliptical mode of expression for der Knabe welcher klug und artig ist, the boy who is prudent and polite); consequently adjectives placed in apposition are treated as predicative.

Some adjectives are always predicative, never attributive; as—

bereit,	ready.	irre,	wrong, astray.
feind,	hostile.	kund,	known.
getrost,	of good cheer.	leid,	distressing.

Adjectives which are predicatively used mostly terminate in consonants. Some end in the diphthongs au, eu, ei; as grau, gray, treu, faithful, frei, free; and several in e; as blöde, bashful, bange, anxious, enge, narrow, böse, bad or angry.

Other adjectives are never predicative, but are always attributive. To this class belong all superlatives and ordinal numbers; adjectives derived from the names of materials by the affix en; many with the affixes isch, lich, and ig, especially those derived from pronouns or particles; as meinig, mine, heutig, of to-day, dortig, there (from dort, there).

Some adjectives are never declined, and others only when an article or pronoun precedes them. Of the first kind are those ending in lei; as einerlei, of one or of the same kind; zweierlei, of two kinds; allerlei, of all kinds; as well as einander, one another, each other; as allerlei Bier, beer of all kinds; mit einander, with one another. Of the second class are ganz, all, whole, halb, half; as (1) without an article or pronoun, ganz Deutschland, all Germany; halb Frankreich, half (of) France; (2) with an article or pronoun, der ganze Stamm, the whole tribe; genitive des ganzen Stammes, &c.; diese ganze Stadt, this whole town.

The adjectives viel, much, and wenig, little, may be used in the undeclined form before substantives; as viel Milch, much milk; wenig Milch, little milk. But they ought always to be declined when they stand alone; they then take the number and gender of the noun to which they refer. Wenig is even left in its adverbial state though a preposition should go before; as mit wenig Geld, with little money. Viel after a preposition is generally, but not always, declined.

Adjectives are declined in three different ways, according as they happen to be—

I. Without an article; as guter Mann, gute Frau, gutes Pferd.

II. Preceded by the definite article or by a word of the same termination; as der gute Mann, die gute Frau, das gute Pferd.

III. Preceded by the indefinite article or a possessive pronoun; as ein guter Mann, eine gute Frau, ein gutes Pferd.

In general, if the article or pronoun which precedes the adjective is strong, the adjective must be weak; if the article or pronoun is weak, the adjective must be strong; if the adjective is not preceded by any article or pronoun, the adjective is always strong. This arrangement seems to rest on the principle that the ending of the definite article, as denoting gender, number, and case, must be expressed before a noun in some way, either by the article or the adjective, and that if once expressed it need not be repeated.

I. When there is no article before the adjective it takes the same terminations as the definite article, except in the genitive case singular (to which it may add en instead of es), and in the singular of the nominative and accusative neuter (in which it changes as into es); thus:—

SINGULAR.

Masculine.	Feminine.	Neuter.
N. guter Vater.	gute Mutter.	gutes Kind.
G. gutes (en) Vaters.	guter Mutter.	gutes (en) Kindes.
D. gutem Vater.	guter Mutter.	gutem Kinde.
A. guten Vater.	gute Mutter.	gutes Kind.

PLURAL.

Masculine.	Feminine.	Neuter.
N. gute Väter.	gute Mütter.	gute Kinder.
G. guter Väter.	guter Mütter.	guter Kinder.
D. guten Vätern.	guten Müttern.	guten Kindern.
A. gute Väter.	gute Mütter.	gute Kinder.

Decline for practice:—

großer Mann,	great man.	weiße Lilie,	white lily.
hoher Baum,	high tree.	weißes Papier,	white paper.
blaue Farbe,	blue colour.	schönes Buch,	fine book.

When adjectives in el, en, and er are declined they frequently drop the e before the final letters l, n, and r; as der edle Fürst instead of der edele Fürst, the noble prince. The adjective hoch, high, when inflected, softens ch into h; as der hohe Thurm, the high tower.

If several adjectives precede a substantive without an article, the first is of course declined like the definite article, and the other, in the singular, according to form III. given below. In the plural, they may all be declined like the article —nom. guter alter Freund; gen. gutes alten Freundes; nom. plural, gute alte Freunde; dieser mein guter Sohn, this my good son. One pronoun, however, does not affect another; as das Haus dieses meines guten Sohnes, the house of this my good son.

II. When the adjective is preceded by the definite article and those pronouns and indefinite numerals which indicate the gender like the definite article; as dieser, diese, dieses, this; welcher, welche, welches, which; mancher, manche, manches, many; jener, jene, jenes, that. In this form the adjective takes the endings of the *weak declension*, except in the accusative singular, in which the masculine ends in en, but the feminine and neuter in e (the same as the nominative). In the plural the adjective has the termination en in all its cases.

When more than one adjective precede a substantive, they have, in this form of declension, all the same termination; as der gute, alte, redliche Mann, the good, old, honest man; gen. des guten, alten, redlichen Mannes.

SINGULAR.

Masculine.	Feminine.	Neuter.
N. der gute Vater.	die gute Frau.	das gute Kind.
G. des guten Vaters.	der guten Frau.	des guten Kindes.
D. dem guten Vater.	der guten Frau.	dem guten Kinde.
A. den guten Vater.	die gute Frau.	das gute Kind.

PLURAL.

Masculine.	Feminine.	Neuter.
N. die guten Väter.	die guten Frauen.	die guten Kinder.
G. der guten Väter.	der guten Frauen.	der guten Kinder.
D. den guten Vätern.	den guten Frauen.	den guten Kindern.
A. die guten Väter.	die guten Frauen.	die guten Kinder.

Decline for practice:—

der grüne Baum,	the green tree.
der blaue Himmel,	the blue sky.
die hohe Tanne,	the high fir-tree.
die prächtige Kirche,	the splendid church.
das neue Jahr,	the new year.
das liebe Kind,	the dear child.
dieser schöne Garten,	this pretty garden.
welches blaue Buch?	which blue book?

When a personal pronoun, ich, du, wir, ihr, sie, occurs before an adjective, the adjective receives, according to the practice of the best authors, the termination of this form, not only in the nominative, but also in the dative and accusative; as ich armer Mann, du gute Frau, du gutes Kind.

When the adjective is preceded by a genitive case, it retains the characterizing inflexion; as Eduard's jüngster Bruder, Edward's youngest brother; Marien's größtes Glück, Mary's greatest fortune. Also when it is preceded by pronouns or numerals, either indeclinable or used without terminal inflexion; such as etwas, some; viel, much; nichts, nothing; genug, enough; allerlei, of all kinds; einerlei, of one kind; zweierlei, of two kinds, &c.; dergleichen, such-like; lauter, mere, nothing but; solch, such; zwei, two; drei, three, &c.; as etwas gutes Fleisch, some good meat; dergleichen harte Worte, such-like harsh words; lauter gediegenes Gold, nothing but solid gold; mit etwas weißem Papier, with some white paper.

III. When an attributive adjective has the indefinite article (ein, eine, ein) before it, it takes in the nominative singular er in the masculine, e in the feminine, and es in the neuter gender; in the other cases en, except in the accusative singular of the feminine and neuter gender, which is like the nominative singular.

EXAMPLES.

N. ein fleißiger Knabe,	a diligent boy.
G. eines fleißigen Knaben,	of a diligent boy.
D. einem fleißigen Knaben,	to a diligent boy.
A. einen fleißigen Knaben,	a diligent boy.
N. eine gehorsame Tochter,	an obedient daughter.
G. einer gehorsamen Tochter,	of an obedient daughter
D. einer gehorsamen Tochter,	to an obedient daughter
A. eine gehorsame Tochter,	an obedient daughter.
N. ein scharfes Messer,	a sharp knife.
G. eines scharfen Messers,	of a sharp knife.
D. einem scharfen Messer,	to a sharp knife.
A. ein scharfes Messer,	a sharp knife.

Adjectives are also declined as above when preceded by the determinative word kein, no, or by one of the possessive pronouns mein, dein, sein, unser, euer, ihr, my, thy, his, our, your, their, and if preceded by any of these words in the plural they take the termination en in all cases; as—

Mas.	Fem.	Neut.
N. keine guten Männer,	Frauen,	Kinder.
G. keiner guten Männer,	Frauen,	Kinder.
D. keinen guten Männern,	Frauen,	Kindern.
A. keine guten Männer,	Frauen,	Kinder.

Decline for practice:—

ein lieber Vater,	a dear father.
mein guter Bruder,	my good brother.
eine blaue Blume,	a blue flower.
deine treue Freundin,	thy faithful friend
ein kleines Opfer,	a small sacrifice.
ihr rothes Tuch,	their red shawl.

Translate the following phrases:—

der gute Vater.	guter Vater.
die gute Mutter.	gute Mutter.
das gute Kind.	gutes Kind.
ein guter Vater.	der Vater ist gut.
eine gute Mutter.	die Mutter ist gut.
ein gutes Kind.	das Kind ist gut.

COMPARISON OF ADJECTIVES.

Qualities assigned to persons or things may exist in them in different degrees, for which reason the adjectives, which are words denoting qualities, are capable of degrees of comparison.

There are three degrees of comparison: the positive, comparative, and superlative.

The *positive* expresses the simple quality of an object; as klein, little, groß, great, weise, wise, &c.

The *comparative* signifies a greater or less degree of the quality of an object, and is formed by adding er to the positive (r only when the positive already ends in e); as kleiner, smaller, größer, larger, weiser, wiser, &c. But words ending in el drop the e when the er is added; as edel, noble, edler, nobler.

The *superlative* expresses the highest degree of the quality of an object, and is formed in two ways:—

(1) When the adjective is joined to a substantive, the superlative is formed by adding est when the final sound of the adjective is a lingual consonant (d, t, s, ß, sch, z), or only st when the adjective ends in any other consonant or in e; as der kleinste, the smallest; der größeste, the largest; der weiseste, the wisest. Participles, however, though ending in end or et, add in the superlative degree only st; as verfeinert, polished; verfeinertst, most polished; blühend, flourishing; blühendst, most flourishing.

(2) When the adjective is not joined to a substantive the superlative is formed by adding sten and placing the word am before it, in the same way as we do the word "the" in English; as am kleinsten, (the) smallest; am größten, (the) largest; am weisesten, (the) wisest.

In most *monosyllabic* adjectives the vowels a, o, u change into ä, ö, ü in the comparative and superlative; as—

Positive.		*Comparative.*	*Superlative.*
lang,	long,	länger,	längst or am längsten.
stark,	strong,	stärker,	stärkst or am stärksten.
kurz,	short,	kürzer,	kürzest or am kürzesten.

But the following monosyllables do not modify the vowel in the comparative or superlative:—

falsch,	false.	los,	loose.	sanft,	gentle.
froh,	joyful.	matt,	languid.	satt,	satiate.
glatt,	smooth.	platt,	flat.	stolz,	proud.
hohl,	hollow.	roh,	rough.	stumm,	mute.
hold,	graceful.	schlank,	slender.	toll,	foolish.
lahm,	lame.	starr,	rigid.	voll,	full.

The comparative and superlative degrees are declined like the positive; as der kleine Tisch, the small table; der kleinere Tisch, the smaller table; der kleinste Tisch, the smallest table; ein kleinerer Tisch, a smaller table; ein schöneres Buch, a more beautiful book; des kleinsten Tisches, of the smallest table.

The following peculiarities and exceptions should be carefully noted:—

The comparative is formed with mehr, more, if two predicates or attributes relating to the same subject are compared and the word than is translated by als; as Er ist mehr klug als rechtschaffen, He is more prudent than honest.

"As . . . as" is translated by ebenso . . . als (or wie); as Er ist ebenso alt als (or wie) du, He is as old as thou; and "not so . . . as" is rendered by nicht so . . . als (or wie).

"The . . . the" is translated by je . . . desto; as je höher desto kälter.

The superlative is rendered emphatic by compounding it with the genitive aller; as allerliebst, most charming (of all).

The absolute superlative is commonly expressed by höchst, most, but also by überaus, exceedingly, and äußerst, extremely; as höchst angenehm, most pleasant; äußerst gütig, extremely kind.

A great many compound adjectives are, by their nature, equal to superlatives; as—

bettelarm,	as poor as a beggar.	nagelneu,	entirely new.
eiskalt,	cold as ice.	uralt,	very old.
feuerroth,	as red as fire.	wunderschön,	wonderfully pretty

Among the irregular adjectives and adverbs are—

bald,	soon,	eher,	am ehesten.
gern,	willingly,	lieber,	am liebsten.
gut,	good,	besser,	am besten or der beste.
hoch,	high,	höher,	am höchsten or der höchste.
nahe,	near,	näher,	am nächsten or der nächste.
viel,	much,	mehr,	am meisten.

Wenig has, besides its regular comparative and superlative, also the irregular form minder and mindest. Recht has a comparative and superlative, which is formed of richtig; as comparative, richtiger; superlative, richtigst. Der, die, das äußere, outer, innere, inner, obere, upper, untere, under, with the superlative äußerst, innerst, oberst, unterst, are formed of the adverbs außen, without, innen, within, oben, above, unten, below, and have no adjective form for the positive. Erster, letzter (first, former, and latter), superlatives, either in meaning or as with letzter, also of origin, form a comparative, ersterer and letzterer.

EXERCISE.

Write out a translation of the following sentences; give (1) the positive, comparative, and superlative of each adjective; (2) place either the definite article (der) or the indefinite (ein) before each noun; and (3) decline in full, *i.e.* giving all its genders, numbers, and cases:—

Der Schnee ist (is) weiß. Die Dinte ist schwarz. Die Asche ist grau. Grün ist das Gras. Blau ist der Himmel. Gelb ist der Schwefel. Das Blut hat (has) eine rothe Farbe. Der Taback hat eine braune Farbe. Der süße Sucker. Das schwere Blei. Das Bier schmeckt (tastes) bitter. Der große Mann. Das kleine Kind ist schwach. Der Baum ist höher als der Strauch. Der Stamm ist dicker als der Ast. Der Ast ist dicker als der Zweig. Die Straße ist breiter als der Pfad. Der Fluß ist breiter und tiefer als der Bach. Das Schaf ist älter und größer als das Lamm. Das Lamm ist holder als das Schaf. Je älter desto größer wächst (grows) das Lamm.

ENGLISH GRAMMAR AND COMPOSITION.

CHAPTER III.

ADJECTIVES—DEFINED AND CLASSIFIED.

ETYMOLOGICALLY the word *thing* is related to the mental act of *thinking*. Whatever we can so think about as to make them distinct objects of thought, grammarians call things. The word in this sense includes persons, places, and other actual existences, as well as any clear idea to which we may give a specific (ideal) reality. The names of our ideas are nouns. All nouns come to be connected in our minds with some qualities, peculiarities, properties, conditions, habits or specialities, which mark them off as different one from another, and which therefore distinguish them. To register to ourselves, and to indicate to others, these distinctive off-marking and determining particulars which characterize and individualize things, we use words which are joined to nouns, and are therefore called adjectives (Latin *adjectivus*, able to be annexed or attached to something else). An adjective is a word used along with a noun to denote some limiting quality, attribute, or distinction which we regard as marking-off in thought that special thing of which we are speaking from others of the same kind or class. It is not the *name*, but the denotive or *sign* of a quality. *Bright* denotes the capacity of giving forth radiancy; *brightness* names it. Nor does an adjective, as is so often said, denote the quality of a *noun*. It denotes the quality of the thing, in the etymological sense, which the noun names. The word *rose* is a noun, but the word *white* does not denote any quality of the word

rose. *A white rose* is, in reality, a new compound description of an ideal—considerably more limited than the word rose—now present in our minds; *white* denotes the quality of the thing, but not of the name *rose*. An adjective has no complete meaning of its own. It has no really independent meaning unless when thought of in connection with a noun. Sometimes, it is true—because we do not always express all that we have in our minds, when we know that what is not expressed will be quite well understood as meant—it seems to be otherwise; and adjectives are frequently used without having the nouns to which they refer expressed. We say, for instance, "The *good* alone are *happy*;" but we mean "Good *people* alone are happy *people*." "As *usual*, he is late," signifies "As is his usual habit, he is late," and it is so in all similar cases.

The objects which surround us are innumerable, taken singly and apart, as individuals; but they are not infinite in their variety as classes. They are all, in a certain way, repetitions of the same or nearly similar qualities. These qualities we can form ideas of, and these ideas we can arrange, assort, classify, combine, and separate. We note things as affecting us in a particular manner, and as exerting activities one upon another. Thus we classify things in thought, and register them in our memories as possessed of certain qualities. Qualities are, in fact, the determining characteristics which enable us to know things one from another. The ideas we have of them are all gained by the comparison of one thing with another, and we define and mark off things by indicating their qualities. Resembling classes are formed by recognizing their likeness in qualities. The precise specific qualities which we take notice of in things varies with our design in looking at them. A piece of mahogany lies before us; regarded geometrically we say it is so long, so broad, so thick, round, square, &c.; thought of as a carpenter would consider it, it is hard, firm, compact, well-coloured, grained, &c. A botanist and a chemist would find other qualities to engage their attention. Each one adds to and aggregates around this bit of wood the characterizing qualities which distinguish it in his mind, and these distinguishing words are all able to be added to the name given to it as adjectives. Adjectives are the marks which we use to denote the qualities which we have observed when comparing things one with another. Thus, we distinguish one man as brave, another as cowardly; one strong, another feeble; one wise, another ignorant. In this way they are all more or less suggestive of comparison, and therefore of limitation. If we say, "Paul is a *clever* lad," we withdraw him from the whole class *lad* into the more limited subclass *clever lad*, and suggest that there are left apart from him those which, if not actually stupid, are at least not clever.

Every kind of thing possesses qualities by which it impresses our senses or our minds. The knowledge of these qualities is often of great interest and importance to us. Many of them lie, as it were, on the surface, and are easily perceived. But they are frequently of such a nature that they are constantly changing, undergoing some variation, and sometimes even disappearing from view. The grass, for instance, may be *growing*, *green*, *withered*, or *cut*. Those words which indicate the permanent or fleeting qualities of the grass are adjectives. They may be called *descriptive*, because they aid us in bringing clearly before the mind the special appearances things present to us, the state they are in, or the qualities which characterize them. Many of the qualities of persons or things are not easily perceived, but are discerned only after observation and search. Thus, a man may be *kind*, *handsome*, *learned*, and *influential*, or *cruel*, *ugly*, *ignorant*, and *worthless*. Such words, expressive of the distinctions of man from man, are adjectives, because that to the idea raised in the mind by the word man they add the limiting variable qualities which these words suggest to the more general idea. These are (from Latin *qualis*, of what sort?) called qualitative adjectives, *i.e.* adjectives which denote the qualities of things, as *wise*, *honest*, *amiable*, *magnificent*, *invulnerable*.

Descriptive adjectives may be of various kinds, viz.:—

I. Proper—being derived from proper names, as Hebrew, Teutonic, Roman, English, &c.

II. Common—denoting the general qualities of things, as green, hot, generous, &c.

Of common adjectives there are four classes—

(1) Those which denote qualities appreciable by the senses, and hence regarded by us as *real*, as sweet, sour, red, gray, large, globose.

(2) Those which denote characteristics perceptible only by the mind as the realizer of ideas, and therefore designated *ideal*, as educated, intelligent, true, right, exemplary.

(3) *Participial*, such as are etymologically derived from verbs, but which are used without the verbal reference to time, as the *seeing* eye, the *uplifted* hand; and

(4) *Numerals*, which will be referred to in a subsequent paragraph. (See p. 243.)

Adjectives are used (1) attributively—*i.e.* as the complements, qualifiers, or modifiers of the ideas expressed by the nouns to which they are added; *e.g.* "A pretty wooden toy was given to James." This does not signify merely that a toy was given, but a toy of a particular description. It was a toy distinguished from others by being "pretty" and by being "made of wood." (2) Predicatively, that is, as complements to verbs, "John is a sensible, well-educated, and industrious tradesman." This is a very different statement from the simple sentence, "John is a tradesman." That he is, indeed, asserted to be, but he is marked off from the whole class tradesman, of which he is one, by the several descriptive distinctions of being "sensible," which all tradesmen may not be; "well-educated," which all tradesmen are not; and "industrious," which is not able to be said of all tradesmen. The assertion is made, not regarding that which the noun alone denotes, but of the idea which the noun and all these adjectives taken together make up. As a complement of a verb, the adjective appears in such sentences as these, Joseph was *faithful*—*i.e.* Joseph was a faithful steward. The fields are *ripe*. His determination was *right*. The man is *ignorant*. Rome grew *powerful*. Burns became *famous*. Mary seems *cold*. He turns *white* with fear. I feel *comfortable*. Virtue makes men *happy*. I was struck *dumb*. Socrates was named the *wise*. The man was considered *trustworthy*.

COMPARISON OF ADJECTIVES.

Many qualificative adjectives are compound, that is, formed from two or more words joined together generally by a hyphen, as milk-white, open-handed, three-cornered. Qualificative adjectives, as they often refer to variable qualities, indicate, when possible and requisite, the degree of variation brought under consideration; as bright, brighter, brightest. Adjectives expressive of such qualities vary in *form*—or, as it is called, undergo inflexion—to indicate the degree or variation in the relative amount of the quality denoted by the distinguishing word. We have an idea of largeness, and this we indicate by the use of the adjective *large* prefixed to the name of things having that quality; as a *large* house. But the relative degree of the quality of greatness in size differs in different things, *e.g.* a horse, a camel, and an elephant may each be spoken of as *large* animals; yet each of these, as it varies in size from the others, may have that difference indicated in a way by saying—The horse is a *large* animal; the camel is *larger* than the horse; and the elephant is the *largest* of these three animals. When we wish to make a simple comparison between two things possessed of the same quality, and to state that one has a greater or a less degree of that quality than the other, the particular amount of the quality possessed by, or noticeable in, the one is placed before us as the unit of comparison for the time being, and is therefore called the positive degree (from Latin *positus*, placed). That which is regarded as showing a greater degree of that same quality than the other is thought of as possessing is said to be *compared* with it (Latin *comparo*, I bring together to see how they match). This possession of an additional amount of the quality is indicated by the addition of the termination *r* or *er* to the simple or positive form of the adjective; and the adjective is then said to be in the *comparative degree*; as fine, fine*r*; bold, bold*er*. When we wish to denote the possession or manifestation of the third degree of a quality—that is, the greatest amount of

which indication is made by inflexion—we add *st* or *est* to the simple or positive degree, and the adjective is then said to be in the superlative degree (Latin *super*, above or beyond; and *latus*, carried—*i.e.* carried beyond the comparative), as fin*est*, bold*est*.

This terminational form of comparison, however, is in general confined to adjectives of one syllable and such dissyllabic adjectives as end in *ble*, *er*, or *y*, as noble, nobl*er*, nobl*est*; tender, tender*er*, tender*est*; merry, merri*er*, merri*est*, &c. In dissyllabic adjectives ending in *y*, preceded by a consonant, that letter is changed into *i* before affixing the augment; and monosyllabic adjectives ending in a consonant preceded by a single vowel double the final consonant, as hot, hot*ter*, hot*test*; thin, thin*ner*, thin*nest*. This, however, is an orthographical rather than a grammatical necessity, and is required to preserve the sameness of sound.

Many adjectives, however, as they denote qualities which are not subject to variation, undergo no change. Among these are:—

1. Proper adjectives, which are not susceptible of comparative inflexion; as British, Johnsonian, Mosaic, Victorian; except in some such phrase as, "More English than the English themselves."

2. Adjectives denotive of *figure;* as angular, square, circular, polygonal, &c.

3. Adjectives indicative of *material;* as wooden, golden, coralline, granitic, &c.

4. Adjectives expressive of *time;* as hourly, daily, weekly, monthly, annual, &c.

5. Adjectives which in themselves indicate the highest or lowest degree of a quality, of which the following are a few:—

Almighty	Fatherly	Living	Royal
Brotherly	Filial	Lunar	Safe
Certain	Fluid	Maternal	Single
Chief	Free	Native	Sisterly
Continual	Full	Non-suited	Solar
Co-ordinate	Gratuitous	Parallel	Solid
Dead	Heavenly	Paternal	Supreme
Earthly	Hereditary	Perfect	Terrestrial
Empty	Immediate	Perpetual	Triangular
Eternal	Impossible	Principal	True
Everlasting	Infinite	Rectangular	Uninterrupted
External	Insular	Regular	Unique
Extreme	Insurmountable	Remaining	Universal
Fallen	Left	Right	Void

6. Adjectives denoting quantity; as ten, hundred, thousand.

7. Demonstrative adjectives; as this, that; pl. these, those.

8. Definite adjectives; as one, five, sixth.

9. Most compound adjectives; as life-long, many-sided, red-crested, only-begotten, thousand-fold, &c.

10. Nouns used as adjectives; as stone walls, iron fetters, prison fare, Aylesbury ducks, &c.

A large number of adjectives of two syllables, and almost all of more than two syllables, take what may be called the adverbial form of comparison. This is done by prefixing to the adjective the incrementive adverbs, more and most, or the decrementive adverbs, less and least. This gives us, in all, a range of five degrees of the intensity of any quality so compared, *e.g.*:—

Least happy, less happy, happy, more happy, most happy; least wretched, less wretched, wretched, more wretched, most wretched; least memorable, less memorable, memorable, more memorable, most memorable; least courageous, less courageous, courageous, more courageous, most courageous; least cowardly, less cowardly, cowardly, more cowardly, most cowardly.

It is obvious, from the above examples, that there is always in the mind some tacit but readily understood standard-point adopted by us as that from which the comparison starts. This is *posited*, *i.e.* regarded as fixed, positive. Many of the words employed to express the positive degree are already pretty long. The addition of a terminal syllable to a long word is not often desirable. The inexpediency and inconvenience of affixing an augment to such words has led to the adoption of this adverbial mode in most cases as a euphonic improvement; for though such words as disagreeablest, magnificentest, indeterminedest, have been used, they do not readily commend themselves to one's ear, even if they did so to one's thoughts. Though Milton uses "artificialest" and Shakspeare "violentest" they have not been generally followed in doing so. It is difficult to lay down any general rules on this subject, and the nearest approach to a principle of guidance we can give is, that when an adjective terminates in a heavy syllable—whether from having a long vowel, or a diphthong, or an accumulation of consonants—the adding of the augment, as it would increase the disagreeableness of the sound, is to be avoided. Yet even in this, practice is not uniform; we say *pleasant*, *pleasanter*, *pleasantest*, but we do not often say *prudenter* or *prudentest*.

Some other forms of denoting the increase or diminution of a quality, and so of—in a way—suggesting a comparison, are frequently employed, such as adding a diminishing affix like *ish* to the adjective, *e.g.* A greenish tint; prefixing another comparative adjective like *rather*, *e.g.* You are rather late this evening; or some such indefinitely modifying word, as *somewhat*, *a little*, *much*, *almost*, *so*, &c., *e.g.* I am somewhat angry. We can also use such expressions as—rather larger; a good deal more handsome; very much better; he is a truly good man.

Such phrases as the last might be regarded as independent superlatives. They do not directly bring the person or thing into comparison in the same sentence with other persons or things having the same quality, but state an estimate formed of such persons or things by themselves. The sentences—These apples are *very good;* our companions are *truly worthy* of friendship; she is *extremely cautious;* I cannot refrain from expressing *the very great pleasure* I have had—do not imply comparison with other apples, companions, women, or pleasures than those mentioned, as the inflected or formally adverbial comparison would do, but indicate, as those composite comparisons always do, distinct attributive qualities which the nouns possess considered in themselves.

The comparison of (1) equality is made by the use of *as* before and *as* following the adjective: James is as industrious as his cousin; (2) of inferiority, by *not so* before and *as* after it: John is not so affable as William; (3) of superiority, by using *than* after the comparative: Mary is merrier than Jane. By employing such words as *extremely*, *exceedingly*, and other adverbs, we express a composite superlative of eminence as distinguished from the superlative of comparison. The same is accomplished by such forms of speech as—the wisest of the wise; the bravest of the brave.

The regular inflexional terminations of comparison are, as we have seen, *r* or *er*, and *st* or *est*. There are some adjectives, however, which take forms which are more or less irregular. For instance, into *far* (Saxon *faran*, to go) a euphonic *th* has been introduced to lengthen the first syllable. It is compared far, far*th*er, far*th*est. By the Scotch this word is colloquially used in the regular form, far, farer, farest. Similarly in *fore*, besides changing *o* into *u*, we use the same lengthening *th*, fore, further, furthest; in addition to which we also compare this word fore, for*mer*, fore*most*. The etymological distinction between these adjectives has been almost entirely lost sight of. Far implies *increase* of distance—going from; fore *decrease* of distance, coming nearer to the front or forward, and thence, more easily distinguished.

The following adjectives have double inflexional forms, viz.:

Late	Later	Latest	(after some usual or fixed time).	
	Latter	Last	(subsequent in absolute time or place).	
Nigh	Nigher	Nighest	in Saxon	Nieh and Neah
				Neor
	Near	Nearest or Next		Nyhste with *hs* like *ks*.
Old	Older	Oldest	(in number of years).	
	Elder	Eldest	(in priority of birth).	

Several adjectives derived from the Latin retain the comparative form they possessed in that language; among them are—anterior, exterior, interior, inferior, junior, major, minor, posterior, prior, senior, superior, ulterior; but they rank only as positives, as may be easily seen from the fact that *than* cannot be used after them as is the case with ordinary comparatives. The same may be said of after, former, hinder, inner, latter, nether, outer or utter, under, upper, when used as adjectives; they are comparative in *form* rather than in *nature*.

Many words having an adjectival meaning are defective in one or more of their parts—*e.g.*

Aft	After	Aftermost.
East	—	Eastmost.
Eld	Elder	Eldest.
Far	Farther	Farthest or farthermost.
Fore	Former / Further	Foremost or first. / Furthest.
Hind	Hinder	Hindmost or hindermost.
In	Inner	Inmost or innermost.
Low	Lower	Lowest or lowermost.
Mid	—	Midmost.
Middle	—	Middlemost.
Beneath	Nether	Nethermost.
North	—	Northmost.
Northern	—	Northermost.
Out	Outer / Utter	Outmost. / Outermost. / Utmost.
Rathe	Rather	—
Rear	—	Rearmost.
South	—	Southmost.
Top	—	Topmost.
Up	Upper	Uppermost, upmost.
West	—	Westmost.

It is rather singular that in the best known languages, ancient and modern, there are some words of similar signification which are irregular in their comparison. Of these are—

Good	Better	Best.
Bad, evil, or ill	Worse	Worst.
Much or many	More	Most.
Little	Less	Least

These words, transmitted as irregulars from the remotest periods to which language can be traced, are logically rather than etymologically—*i.e.* in use more than in origin—related to one another.

No adjective requires both the inflectional and adverbial forms of comparison—*e.g.* "*most* straitest" is improper.

When one noun precedes another, as in "steel-pen," "morning-star," &c., it is in our opinion better to call the two collocated words a compound noun, than, as is usually done, the former an adjective.

A few adverbs admit of inflexion by comparison, like adjectives; as soon, sooner, soonest.

Besides descriptive or qualificative adjectives, which define and limit by statement of characteristics, there is another class of adjectives which may be regarded as definites. They may also, from their peculiar nature, as having reference to number and quantity, be classed as *numerals.*

Numeral adjectives may be either (1) definite or (2) indefinite.

Definite numeral adjectives are either (1) cardinal, (2) ordinal, (3) multiplicative, or (4) partitive.

Cardinal numerals express numbers in their simplest form; as one, two, three, &c.

Ordinal numerals denote the actual place or rank held in a series or orderly arrangement of things; as first, second, third, fourth, fifth, &c.

Multiplicative numerals show the number of the parts of which a whole is composed; as single, double, triple or treble, quadruple or fourfold, &c.

Partitive numerals indicate the divisions which have been made in a whole; as half, third, quarter, twelfth, &c.,

Indefinite numeral adjectives refer either to (1) number, or (2) quantity.

Indefinite numerical adjectives are such as—all, some, many, few, any, none, several, divers, certain, &c.

Indefinite quantitative adjectives are such as—much, little, great, enough, whole, &c.

EXERCISES.—1. Construct a form like the following, and in it insert adjectives similar to those given as examples in the previous lessons in their respective columns.

ADJECTIVES.

Proper.	Common.			
	Real.	Ideal.	Participial.	Numeral.

2. Construct tables like the following, and insert in each of the columns thirty adjectives, properly arranged and compared, as in the example given.

COMPARISON OF ADJECTIVES.

1. INFLECTIONAL.

By *r* or *er*, and *st* or *est* without change.			By adding *er* and *est*, doubling the final consonant.		
Pos.	Comp.	Superl.	Pos.	Comp.	Superl.
Gay.	Gayer.	Gayest.	Hot.	Hotter.	Hottest.

By changing *y* into *i*, and adding *er* and *est*.

Positive.	Comparative.	Superlative.
Dreary.	Drearier.	Dreariest.

2. ADVERBIAL.

By placing *more* and *most* or *less* and *least* before them.

Positive.	Comparative.	Superlative.
Tender.	More / Less tender.	Most / Least tender.

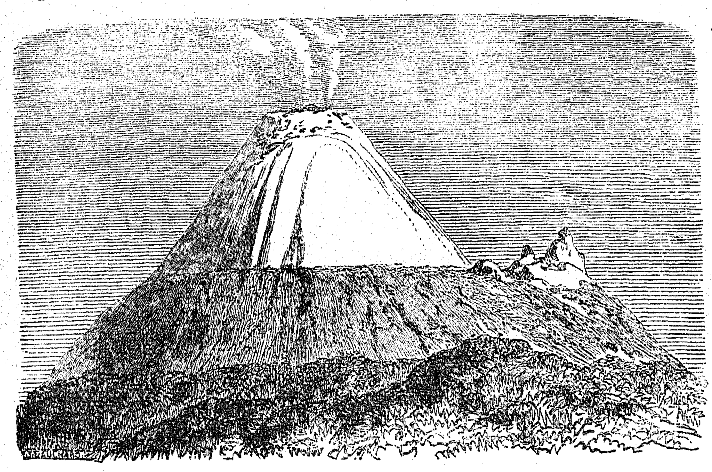
GEOLOGY.—CHAPTER III.

IGNEOUS AGENCIES—SUBTERRANEAN STORMS—SOLFATARAS, FUMAROLES—THERMAL SPRINGS—GEYSERS—FIRE-WELLS—SALSES—VOLCANCITOES AND VOLCANOES.

IN geology the word rock does not necessarily imply massed stone. It is used to signify the matter of which the crust of the earth is composed. In this sense not only granite and marble, but clay and sand, are included in geological *rock.* We have seen how, chemically by change in the atomic composition and properties of the parts of surfaces, and mechanically by alteration in the aggregations of surface-matter, through variations of heat and moisture—the action of carbonic acid and oxygen—the ordinary operations of beating rain, of waterspouts, and inundations—the action of streams, rivers, and waterfalls—the fluctuations of lakes, of water flow, and tide—and the continuous motion of the ocean, rocks are worn down; and their debris enter into new combinations and collocations. Stratifications, whether incipient or complete, show, in the subsidence and settlement of these mixed and suspended materials, that the earth's surface has been varied and changed. We do not find all rocks lying in regular horizontal layers, one superincumbent on the other, as they would be if these external influences were the only causes of change. We know that our globe has been (and is) the theatre of singular subterranean phenomena; jagged peaks, abrupt chasms, and upheaved precipices suggest that the telluric shell has been subjected to derangements of its surface more or less violent. The earthquake and the volcano add their evidence to the fact that igneous action has been effective in change. Common experience contrasts the mobility of water with the immobility of land, and we speak of the crags and mountain-battlements around us as "everlasting hills." But geology reads the great rock-records of the earth differently. It traces the changed aspects of nature to their causes, and among the forces which have operated to bring about the present condition of the visible surface of the globe it includes the interior heat to which we owe fumaroles and geysers, salses and fire-wells, volcanoes and volcancitoes, upheavals, subsidences, and earthquakes.

Modern geologists, with the caution of inductive reasoners, gather full information concerning the known before they proceed to explain the unknown. The acquisition of correct and adequate information regarding phenomena enables them to carry from the present, as it were, the light of experience into the investigation of the evolutions of the past. Following this course, we shall endeavour to present the known phenomena of igneous action as a preparative for applying that knowledge to the interpretation of the unstratified and metamorphic rocks, and of the disturbances of strata which are perceptible everywhere as we look around us.

Pliny long ago called earthquakes "subterranean storms." Sometimes underground sounds are heard like the rolling growl of thunder or the muffled discharges of artillery. These strange noises are propagated through the solid crust of the earth, and are not the re-echoed grumblings of atmospheric perturbations. In 1784 a preternatural roaring was heard in the mining districts around Guanaxato, in Mexico, for more than a month, though the surface of the earth was free from any tremulous motion, and no movement was felt even in the deepest workings of the gold and silver mines. Caraccas, a city in Venezuela, has often been terribly shaken with earthquake. When New Grenada was subjected to a violent earthquake in 1835, the resonance of the intertelluric storm was heard without intermission for seven hours, though no vibration of the earth was felt. During the great volcanic eruption of Cotopaxi, 1738, loud subterranean noises were heard, like far-off cannonading, at Honda, 463 miles distant in a direct line and 18,000 feet lower than the peak whence the eruption sprang, throwing its glare 3000 feet into the air. Earthquake shocks were, however, plainly felt in the silver mines of Marienburg early in this century, yet when the miners in their alarm reached the surface, no sound had been heard, no shock had been felt. Here we have subterranean thunder without eruption or earthquake, concomitant to both, and absent at least in one instance.



Cotopaxi.

We can do no more than mention here the phenomena of *solfataras*. These are rents in and vents of the earth from which—as in the case of the crater at Solfatara (from which they derive their name), above the little Neapolitan town of Puzzuoli—there issue corrosive sulphurous gases and steamy vapours. In the near neighbourhood of these *colles leucogei* (white chalk hills), as the ancients called them, are Lake Avernus, occupying, without outlet, the crater of an extinct volcano; Lake Agnano; the Grotto del Cane, whose mephitic evolutions of carbonic acid seem due to internal heat; and the Temple of Serapis, the changes in the position of which indicate that more than once the relative level of sea and land has been altered. The district gives the name puzzolana to a dull, straw-yellow, harsh-feeling volcanic tuff, through a hill of which, 1513 feet high, at Camalduli, the celebrated Grotto of Pausilippo—2178 feet long, 50 feet high, and 18 feet broad—has been cut. The islands of Procida and Ischia belong to this centre of igneous operations.

We turn now to *fumaroles*, or apertures in the earth whence gaseous vapour or sulphurous smoke is emitted. These are numerous in the volcanic regions of Iceland, where hot steam is ejected to a height of from 30 to 60 feet from crevices in the soil, with a noise resembling that of steam under high pressure rushing through a safety-valve. They occur also along a line of about 25 miles in Tuscany, and boric acid is mingled with the jets of vapour they give out. Of those evidences of elastic fluids finding or forcing their way from the interior of the globe, perhaps the most notable instance is that of the *fire-wells* of China. In Hotsing, through fissures in the earth's crust, vast quantities of carburetted hydrogen have been known for 1000 years to be issuing. By the use of bamboo-cane as piping, this gas has been utilized for lighting purposes, and has even been adopted as the city gas-supply for Kiung-tschen. The evolution of different gases by the operation of natural chemistry among the hidden elements of the earth is a phenomenon familiar to us in mineral springs, and in the accumulations in mines which cause those smoke-damp explosions that so frequently scatter distress and death among mining populations.

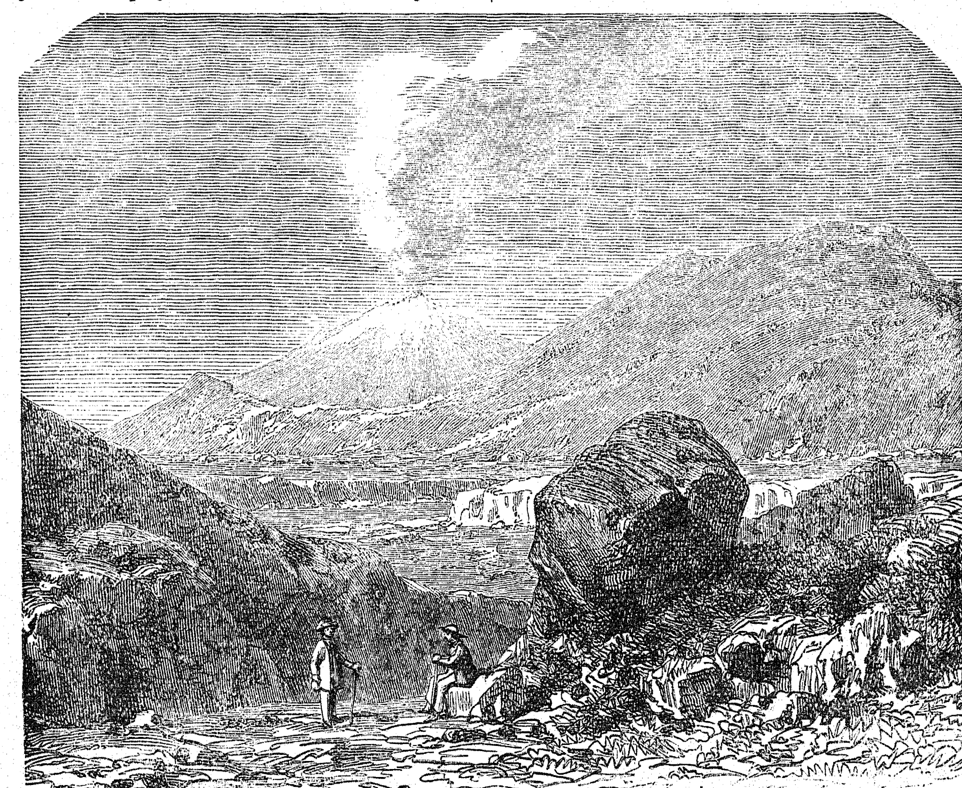
Many *thermal springs* are so impregnated with these subterranean chemicals as to have gained the credit of possessing specific curative powers, and have made their neighbourhoods health resorts. We know that substances in a solid or fluid state, when exposed to the action of heat, undergo a change of condition; the solid becomes fluid, and that aerial or gaseous. The ready absorption characteristic of water is familiar, and hence we have a reason for the solution of mineral matters and their combination with the waters of thermal springs. The temperature of water drawn from the earth by artificial boring shows in general an increase of one degree for each 60 feet in depth below the surface of invariable temperature. We find waters of different temperatures issuing from famous springs. The waters of Bath show 66° Fahr., of Toplitz 71°, of Chaumont 80°, Baden-Baden 96°, Wiesbaden 108°, Carlsbad 117°, Abano 121°, which is also the range attained by the springs of Borset, in the province of the Lower Rhine. During the earthquake at Lisbon the springs at Toplitz ceased for a time to flow, and when the water reappeared it was ochreous in tint. The hot springs of Las Trincheras, in Venezuela, reach a temperature of $194\frac{1}{2}$°, while the Aguas Comangillas, near Guanaxato, in Mexico, are $205\frac{1}{2}$°. These places are near territories in which earthquakes are frequent and volcanoes abound.

Iceland is a high mass of rocks of igneous origin, which, though covered with perpetual snow and glaciers, is pierced by numerous and intense volcanic fires, whose soil emits sulphurous vapours and inflammable gases, and the jets of boiling water ejected from the heart of these lava-masses constitute one of the curiosities of the universe. The most remarkable of these *geysers* are found in a group near Reikiavik, and not far from the volcano Mount Hecla. The Strokr (or churn) is one in which the water can be seen working about 20 feet below the surface of its outlet, but which can be provoked, by stuffing up its gullet, into belching forth a magnificent jet to a height of 60 feet. In the Great Geyser the water, only 20 degrees below the boiling point, boils and eddies impatiently, and every few hours, with a rumbling roaring, projects, in a tumultuous outburst, a stream of thermal water. Once each day a great paroxysm occurs, when it flings into the air repeated jets of water, rising from 60 to 80 feet high, and enveloping the country for a mile's extent in steam. Before these eruptions its waters have been found to have risen to 261° Fahr. They are impregnated with soda and silica. These have encrusted round it into a circular orifice about 72 feet in diameter. In a group near Reikholt there is a double geyser, each part of which throws out a jet in alternation with the other, every few minutes. It is supposed that these eruptions are due to the sudden evolution of steam

produced in subterranean watercourses by the heat of the surrounding volcanic regions. The relation traceable between centres of volcanic action, earthquake perturbations, thermal springs, and gaseous vapours, seems to indicate that they are causatively, not casually, connected.

Another class of igneous phenomena appear to exhibit effects intermediate between the emission of gases and liquids and that of molten matter. These receive the name of *salses* or mud-volcanoes. At their earliest outburst, they are generally accompanied by the ejection of lofty jets of flame, by subterranean noises, and in their subsequent results they are marked by the upswelling of extensive tracts of land. The salses of Macaluba, near Girgenti, in Sicily, and of Monte Zibio, near Sassuolo, in Modena, as well as the Peninsula of Taman, on the east side of the Strait of Kertch, from several cone-shaped mounds, throw up water mixed with mud and charged with carbonic acid and carburetted hydrogen. But it is on the promontory of Apsheron, running out for 40 miles into the Caspian Sea, that the discharges of hot torrents and muddy matter display themselves most remarkably. The fire-worshippers of Asia consider this peninsular projection as sacred soil. At Jokmali, there, in 1827, the flames burst forth from a crater formed by the upblazing soil, burned for a whole day, lighting up the distance for 24 miles, and ejected huge fragments of rock and large quantities of volcanic mud. The ground here is impregnated with salt, sulphur, and naphtha. Sometimes the exuded liquids spread over the sea's surface, and, taking fire spontaneously, show the strange spectacle of a flaming waste of waves extending for miles over the Caspian waters. At Dumak, in Java, where both extinct and active volcanoes abound, mud is ejected at a high temperature.

Of the subsidiary phenomena of these eruptive forces, *volcancitoes* are among the more remarkable. These consist of crater-like openings, often filled with water, and having generally mud wells, out of which there issue elastic gases, apparently proceeding from some reservoir of compressed air or some underground laboratory of gaseous products. At the beautiful village of Turbaco, near Cartagena, one of these air-volcanoes occurs. There are about twenty cones, each



Mount Hecla.

about 80 yards in circumference at the base, 22 feet high, having at their tops craters about $1\frac{1}{2}$ feet wide, full of water coincident in temperature with the air. Through this water there bubbles up an almost pure nitrogen gas. Each vaporous spume contains about 13 cubic feet of this invisible azote, and less than half a minute elapses between each outburst. Other smaller cones in the district emit similar vapour, each apparently having its own communication with the internal reservoir.

These accounts of subterranean agencies of an igneous nature and indications of disruptive powers existing within the earth's crust, united with the evidence of eyesight that much dislocation has taken place in the telluric shell, and our knowledge of the sudden and frequent operation of greatly disturbing shocks of earthquake and eruptions of volcanoes, impart an intense interest to the natural history of the earth and to the startling changes of which its very surface has been the theatre. Those who live in countries where the earthquake and volcano are, practically speaking, unknown, can form no adequate idea of their terrible effects, unless they study the phenomena produced by them, not only in the written histories of such visitations, but also in the crust of the earth itself, shaken and shattered as it is, and has been, by similar causes in remote geological epochs. In the structure of volcanic rocks, the existence of trap dykes, the dislocation of strata, and the undulations which the stratified beds often exhibit, we have the most decided proof that our own land, now so stable, was once subject to similar dreadful convulsions.

Exceedingly little is known as to the real cause of earthquakes. There can be little, if any doubt, however, that they spring from agencies similar to those which produce the volcano—namely, the existence of subterranean heat, and the explosion of gaseous bodies in the regions where they are felt. Whether that heat, or those explosions, are the results of new chemical changes and combinations, or are caused by the existence of incandescent molten matter underneath the solid framework of the earth, it may be, perhaps, impossible for

us distinctly to determine, but it evidently affords scope for inquiry and reflection.

The heat, from whatever source derived, must be intense which not only converts solid rocks into fiery lava, but reduces them into gases which, struggling for vent, burst their way through volcanic craters with force sufficient, in many instances, to project stones of enormous size and weight through the atmosphere to the distance of many miles, or which, not finding that mode of escape, communicate to the ground the tremulous shock of the earthquake, rending, when violent, the solid crust, elevating land tracts, changing river-currents, destroying towns, and burying their inhabitants in a common grave. We are not likely, however, to form proper conclusions regarding causes until we have acquired an accurate knowledge of phenomena. Though it would require large volumes to detail the disastrous occurrences which have attended earthquakes, and the fearful consequences of some volcanic eruptions, yet by a judicious selection of a few of the more salient points of special geological interest we may convey an idea of their most characteristic features.

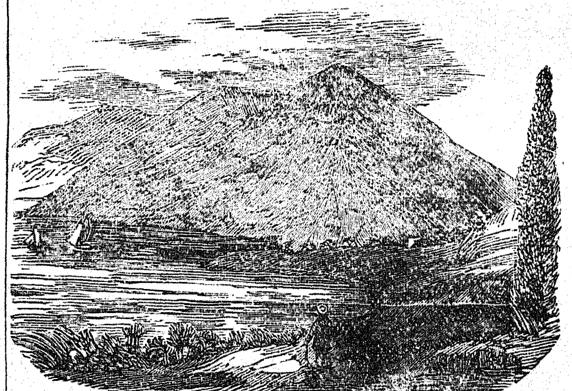
A volcano generally consists of a cone-shaped hill, with a wide crater or chasm at its summit, from which there issue, in times of great activity, flame and smoke, rivers of burning lava, and showers of stone and ashes. The quantity of matter thus poured out is various. Sometimes it overspreads considerable tracts of adjacent territory, and, when consolidated, forms a stratum of rock to the depth of many feet. Sometimes the showers of dust and stones are immense—so much so, in fact, as in the cases of Pompeii and Herculaneum, as to bury whole cities. The eruption of a volcano generally commences with a tremendous explosion, which is succeeded by others less loud, and the escape of gas and vapour from the mouth of the crater. Large fragments of solid rock, and masses of lava, are projected in these discharges, some of which are thrown upward in a perpendicular direction, and fall back into the mouth of the crater, from which they are again discharged. By these means they are often broken into powder and mingled with the surrounding atmosphere, producing the appearance of dense clouds of smoke. The lava then rises to the vent of the mountain, and soon finds egress, either from the crater at the summit of the mountain, or from openings in its sides; the latter is generally the case when the mountain is very high. The noises, which frequently resemble the discharge of artillery, are not so frequent when the lava is issuing from the mountain. When the detonation becomes less frequent, rumbling sounds are heard, as of the rushing of many waters; after which the mountain gradually sinks into a quiescent state, as if wearied with the work of convulsion and destruction. The issue of molten matter may continue for days and even weeks, and its volume is often enormous. In 1687 the lava-flood of Etna gave forth 100,000,000 cubic feet; Vesuvius in 1794 cast out 46,000,000, in 1837, 34,000,000; while from Hecla in 1783 there rushed 40,000,000,000 tons of red-hot matter in two channels, of which one was 40 miles long and 7 broad, and another 50 miles in length and from 12 to 15 in width, besides some small subsidiary streams which discharged into steam the waters of a lake, occupied their place, and filled the water-courses of two rivers—entirely silting up the hollow of a cataract, and in some places rising to a height of 600 feet.

On the east side of the Bay of Naples, isolated in the wide plain of Campania, stands *Monte Vesuvio.* It is 9 miles from the city, and 6 from the bay. It rises 3948 feet above the sea-level. The hollow cone at its summit is about 2000 feet in diameter, and its crater slopes inwardly to a depth of nearly 500 feet. Outside of the cone, and divided from its base by a level space, half a mile wide, rises the mural escarpment of Somna, 1400 feet in height. This wall, and the terrace beside it, are the remains of a truncated cone which inclosed the old crater, out of which the present cone and crater have been projected. During an eruption in October, 1822, no less than 800 feet of the cone was blown up into the air, but by recent eruptions a considerable proportion of this height has been restored. The volcanic products of Somna differ from those discharged out of the inner cone, and within its space a greater number of mineral species have been found than in any other volcanic area of equal extent.

In ancient times Vesuvius had a cone of a very regular form, terminating not, as now, in two peaks, but with a flattish summit. The sides of the mountain were richly cultivated, and at its base stood populous cities. The first eruption of Vesuvius, in the Christian era, occurred in A.D. 79. The cities of Pompeii and Herculaneum were overwhelmed together in that great eruption, and were destined to be partners in disinterment as well as in burial. There was, however, this difference in their fate—that, owing to its greater distance from the volcano, the former was not then, and never has been, reached by the streams of lava which successively flowed over Herculaneum, elevating the surface of the earth from 70 to 100 feet. Pompeii was buried beneath a shower of ashes, pumice, and stones, forming a bed 12 or 14 feet in depth, loose and friable in texture. Their very sites remained unknown till the last century, when the chimneys of the houses were discovered. Considerable portions of both have been excavated, and many curious facts, illustrative of the architecture and arts of the first century, have thus been learned.

Vesuvius had not been, up till this time, suspected of being a volcano, though sixteen years previously it had begun to give indications of being so by a severe earthquake, and several slighter shocks had been subsequently felt. Of the terrible city-engulfing outbreak of 79, Pliny the Younger has given, in two well-known letters addressed to the historian Tacitus, in choice Latin, a most graphic description full of interesting details. Upwards of sixty great and many minor eruptions have since taken place. A few details, selected from accounts by different persons and of different eruptions, will best convey a conception of the disturbing and desolating power of the Vesuvian effluxes. In 472 the ashes that flew from its peak were carried as far as Constantinople. The matter emitted was torrents of mud rather than of lava, and no eruption of the latter sort is mentioned in historic records till 1066.

In 1539 the volcanic hill called Monte Nuova was formed in the Bay of Baiæ, near Naples. It rose to the height of 440 feet, and attained a circumference of 1½ miles. Earthquakes had been very frequent. On 27th and 28th September twenty shocks were felt in twenty-four hours. On the 29th a gulf opened in the ground, and a large fissure or rent approached the small town of Tipergola, which formerly existed on the site of the Monte Nuova. Thence there issued a tremendous noise, accompanied with flame and by discharges of pumice stones, blocks of unmelted lava, and ashes, mixed wth water. Tipergola was overwhelmed. The ashes fell in immense quantities, even at Naples. The sea retired 200 yards, and left part of its bed dry. The coast, for some miles, was upraised many feet above the bed of the Mediterranean. The newly-formed hill presented the appearance of a truncated cone. The crater at its summit is 421 feet deep. In 1631 seven streams of lava poured at once from the crater and overflowed several villages on the flanks and at the foot of Vesuvius. Resina, which had been partly built over the site of Herculaneum, was consumed by the fiery torrent. Violent rains, produced by the evolution of watery vapour, descended from the cone, and, becoming charged with

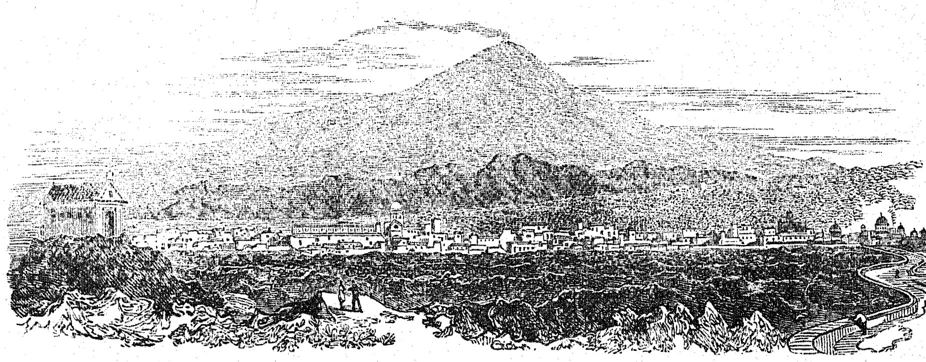


Monte Nuova.

impalpable volcanic dust, and rolling along through loose ashes, acquired sufficient consistency to deserve the appellation of aqueous lava.

Sir Wm. Hamilton, describing the eruption of 1779, mentions that jets of liquid lava, mixed with stones and scoriæ, having the appearance of a column of fire, were thrown to the height of 10,000 feet. The matter, still red-hot and liquid, falling, covered its own cone, part of Somno, and the valley between them. This being nearly as vividly inflamed as that which was issuing from the crater, formed with it one complete body of fire, which could not be less than 2½ miles in breadth, and being of extraordinary height cast a heat to the distance of, at least, 6 miles around it. One mass of rock ejected was 108 feet in circumference and 17 feet high. In an eruption which took place in 1793, Dr. Clark, an eye-witness, tells us that millions of red-hot stones were shot into the air full half the height of the cone itself, and then bending fell all round in a fine arch. The lava, issuing from a curved chasm in the side of the mountain, rushed with the velocity of a flood. It was in perfect fusion and flowed with the translucency of molten gold, glancing with all the splendour of the sun. At the bottom of the mountain the whole current resembled nothing so much as a heap of unconnected cinders from an iron foundry. These torrents form a series of strata. Into the rents of this stratification masses of volcanic matter are sometimes projected, and sometimes they are poured in from above. Eruptive ashes are often scattered round the country to considerable distances, and a large quantity of this product is swept into the sea. During the intervals between the eruptions the matter mixes with other kinds of sediment, with shells and coral, and forms rocks of a mixed character, and these volcanic conglomerates get cemented together.

We turn now to Etna, the largest volcano in Europe. It is about 11,000 feet above the level of the sea, and its base is 87 miles in circumference. Around lies one of the most



Etna from Catania.

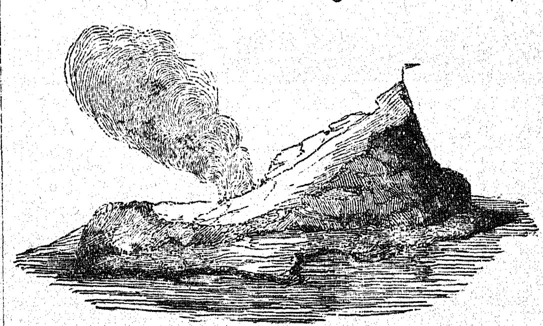
fertile countries in the world—well cultivated, numerously inhabited, and adorned with the richest luxuriance. The vine, the olive, the fig-tree, and many of the richest aromatic herbs, grow there. Ascending from the fertile, we reach the woody region, which encircles the mountain. This consists of immense forests, affording pasturage for numerous flocks. The trees are the oak, the chestnut, the pine, the beech, and the cork, the two latter forming groves of great magnificence and beauty. From the woody we ascend to the desert region—a bleak barren district, overlaid with lava and ashes. Above this plain, from which sulphurous vapours continually issue, the mountain ascends to its vast height. The most singular feature of this volcano is the immense number of cone-shaped hills which flank its woody and lower regions. About eighty of these secondary volcanoes are of considerable dimensions. Some of them measure from 400 to 700 feet in height. These immense cones are produced by eruptions in the mountain side. The crater of the volcano is from 2½ to 4 miles in circumference, and from 600 to 800 feet deep. Etna is situated in that division of Sicily which, in allusion to the old superstitious notion that the flames and smoke of Etna ascend from the region of demons, is called Val Demone.

Stromboli, the most northerly of the Lipari Islands, consists of one single volcanic mountain, 12 miles in circuit, rising 3100 feet out of the sea. It has been called "the candle of the Calabrian coast." It is continually discharging flames, stones, and ashes, though during 2000 years no eruption has actually occurred. Sulphur and pumice-stone are gathered in large quantities by its inhabitants.

A submarine volcano near St. Michael's, in the Azores, in 1811, ejecting smoke and vapour, threw up cinders to the height of 700 or 800 feet above the surface of the water. One of the most remarkable of marine eruptions was that of the formation of Graham's Island, off the coast of Sicily, in 1831. On 28th June Sir Pultney Malcolm, passing over the spot in his ship, felt the shock of an earthquake. At the same time shocks were felt on the west coast of Sicily. On 10th July the captain of a Sicilian vessel reported that as he passed near the place he saw a column of water, 60 feet high, rising like a waterspout from the sea, and soon afterwards a dense steam in its place, ascending to the height of 1800 feet. The same person, on his return, found a small island 12 feet high, with a crater in its centre ejecting

Section of Graham's Island.

volcanic matter, the sea around being covered with floating cinders and dead fish. The eruption continued with great violence till the end of the same month, at which time the island was from 50 to 90 feet high, and three quarters of a mile in circumference. On 4th August Herr Hoffman, the



Volcanic Eruption on Graham's Island.

Prussian geologist, found it 200 feet high and 3 miles in circumference, after which it began gradually to decrease. The island was wholly composed of incoherent ejected volcanic matter, which lay in regular strata, like the cone of Mount Vesuvius. In 1832 Captain Swinburn found a depth of 150

feet where the island had formerly been. But Sir C. Lyell found there, towards the end of 1833, a dangerous reef of an oval figure, in the centre of which was a block of rock of the dimensions of 26 fathoms, and from 9 to 11 feet under water. Round this block were banks of black volcanic stones and loose sand. There was a second shoal 450 feet west of the great reef, with 15 feet of water over it, also composed of rock surrounded by deep sea. We can scarcely doubt that this rock marks the site of the submarine eruptions of 1831. A hill, 800 feet or more in height, was formed by a volcanic vent, of which the upper part (only about 200 feet high) emerged above the waters, so as to form an island.

Volcanoes are found in every quarter of the globe. In America a great number are situated in the provinces of Guatemala and Nicaragua, which lie between Mexico and the isthmus of Panama. An eruption of Consiguina, in that region, broke out on 20th January, 1835. The vapour which rose from its crater is described as very beautiful. It spread over the whole of the surrounding territory; and the obscurity, black beyond description, formed a night of eighteen hours' duration, during which tremulous movements of the earth, strange noises, thunder and lightning, and an impetuous wind impelling a heavy shower of ashes, rendered that night a period of distress and horror. The two next days were melancholy. Through the dense vapours the sun showed a pale saffron-coloured countenance. On the 23rd there commenced a growling and alarming sound, instantly followed by detonations loud as the roar of the largest artillery. The earth shook, and indicated another eruption, which was soon confirmed by the ascent of a volume of smoke. A glare of red light occasionally served to render the darkness visible. The mountain continued to vomit exhalations until the 5th of February. The darkness extended over the whole of Central America for several days, and covered not less than 1500 square leagues with lava and ashes to the thickness of from 2 to 18 inches. A government commission examined the district. A forest that had survived many changes upon the surface of the earth had disappeared; two islands had been founded in the surges and burning billows. About fifty conical islands of varied form and size, containing many craters, rose within, round the edges, or from the surface of the burning lake, some emitting columns of gray smoke and pyramids of brilliant flame; several vomiting streams of lava, which rolled in blazing torrents down their indented sides into the boiling masses below.

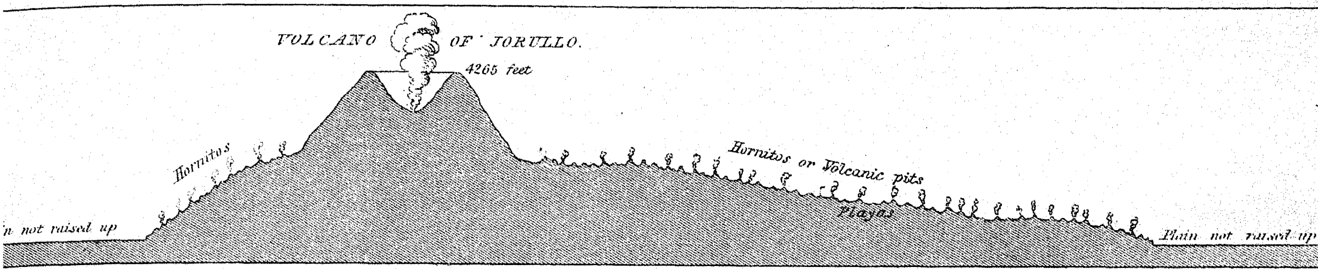
Every part of the south-west extremity of North America, constituting the Mexican territory, bears present witness to the influences of volcanic action in the formation of its contour and variety, though of late vibratory and disruptive phenomena have been less frequent and violent than formerly. The table-lands of Mexico generally slope towards the north, and are girt in by low mountain-ranges, which occasionally rise into lofty peaks, above which again tower such lofty cones as Istaccihuatl ("the white woman"), 15,700 feet, or Popocatapetl ("the smoking mountain"), 17,880 feet. These and other volcanoes form a transverse belt extending from ocean to ocean, and do not follow the inclination of the South American central chain. Besides these, isolated volcanic vents appear, among which, about 150 miles W.S.W. from the city of Mexico, one rising to the height of 1375 feet from the plain of "the Malpays" (see fig. 1, Plate I.) or Mixtecapan, which is itself 2890 feet above the level of the sea, deserves mention.

The volcano of Jorullo (see figs. 1 and 2), one of the wonders of the New World, as Humboldt calls it, is a phenomenon without example in the history of our planet. The seat of this volcano was occupied by fields of sugar-cane and of indigo, between the brooks of Cuitamba and San Pedro. These fields were bounded by basaltic rocks, one of which, on the west, was the Pic of Tancitaro. In June, 1759, alarming subterranean noises were heard by the inhabitants of the Hacienda of San Pedro de Jorullo. Earthquakes succeeded each other thereafter for nearly two months, but ceased during the greater part of September. On the 28th of that month, however, the noises became frightful, and the Indians fled to the Mountains of Aguasarco. An area of about 6 square miles, called the Malpays, rose up in the shape of an inflated bladder, and flames issued from every part of it. Fragments of burning rocks were thrown to great heights, and beneath thick clouds of ashes the molten surface of the ground swelled up and undulated like an agitated sea. The rivers in the neighbourhood rushed into the flaming chasms, and thousands of burning cones, from 6 to 10 feet high (called *hornitos* or ovens), formed of basaltic nodules separating into concentric layers and embedded in black clay, discharged a thick vapour and sent forth a subterranean noise. In the midst of these *hornitos* six huge masses—from 1300 to 1650 feet high, springing from a deep chasm having a N.N.E. direction—rose above the ancient level of the plain, along which the volcanic fire, bursting through the interior crust of the porphyritic rock, made its appearance at different points of the line of volcanic vents, and inflated the bladder-shaped area covered with these *hornitos*. The highest of these masses is the great volcano of Jorullo. It continued to eject basaltic lavas and fragments of primitive rocks till February, 1760. The volcanic ashes thrown out in these eruptions fell thickly on the roofs of the houses of Queretaro, 144 miles distant. Another eruption, accompanied with an earthquake, took place in 1819, when the volcanic ashes fell 6 inches deep in the streets of Guanaxuato, 140 miles distant. Many of the subordinate cones of this volcano have since disappeared, some have changed their form, the ovens have almost ceased to smoke, and the heat of the springs has greatly decreased.

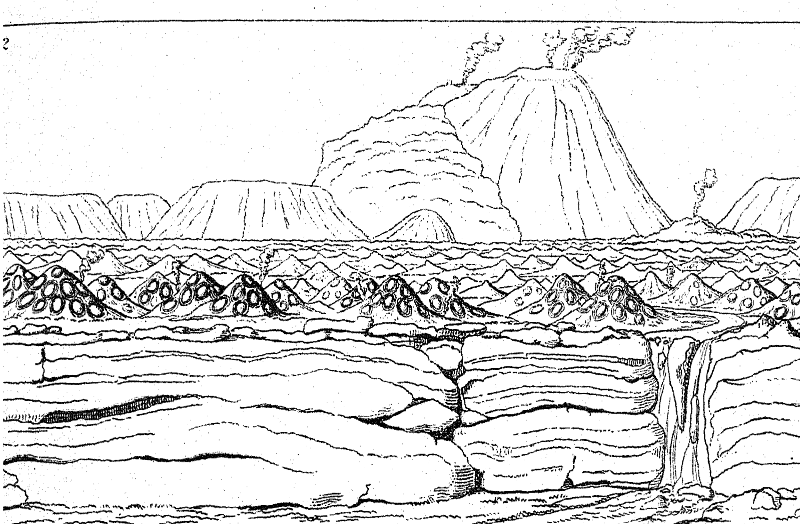
Of the scene of this singular volcanic outburst we present (in Plate I., fig. 2) a view and (in fig. 1) a section, both of which are of great interest as exhibiting the appearance of one of the strangest and vastest of the upheavals of matter from the interior of the earth which has occurred during recent historic record. Though comparatively isolated in place, however, Jorullo is not isolated in cause, for it lies in the oblique line which runs from east to west in the parallel of Mexico, and presents in its course, besides those burning mountains above-mentioned, Orizabat, Coffre de Perote, and Colima, a line which if extended would traverse the group of islands in the Pacific called Rivillagigedo, which are by all geologists regarded as volcanic in their origin. In Nicaragua, Guatemala, and the other states of Central America, a succession of volcanoes lies parallel, instead of transversely, to the chain of the Cordilleras. South of the Isthmus of Darien many active vents are enumerated:—Tunguragua, the Vesuvius of the New World, near the town of Riobomba, in the province of Quito; Tolima, in Bogota, among the Central Andes; Sotaro and Purace, in the vicinity of Popayan-Pesto—during an eruption of which, in 1797, Riobomba (nearly 200 miles south) was destroyed by a fearful earthquake; and Cotopaxi, a volcano 18,878 feet high, which has even recently produced eruptions. In 1738 it threw its blaze nearly 3000 feet above the crater. The ashes which it ejected in April, 1768, darkened the air to such a degree that the inhabitants of Hambato and Tacunga were obliged to use lanterns at mid-day in the streets. The eruption which took place in January, 1808, was preceded by the sudden melting of the snow, and the noises which it sent forth were heard at Guayaquil, 180 miles distant. In fact, the Pacific Ocean seems to be bounded by an almost unbroken succession of active volcanoes, and mountain peaks which show—as does the summit of Rishuicha—the craters of extinct volcanic fires. This we can trace from the Alsatian Islands in the north to Tierra del Fuego in the south. Even in the New South Shetlands (S. lat. 62° 55′) there is an active volcano.

Notwithstanding our rapidly diminishing space we mention another volcano, the phenomena of which are exceedingly interesting. There are numerous islands in the Pacific Ocean composed almost entirely of volcanic matter, and in which active volcanoes still exist. Hawaii is such an island. The whole mass, having a surface of 4000 square miles, is composed of lava or other volcanic matter, which rises in the peaks of Mauna Loa to 13,760 feet, and Mauna Kea to 13,950 feet. The appearance of the latter from the sea, with its abrupt upward start and peculiar dome-like top, is majestic in the extreme. On its eastern slope, at the altitude

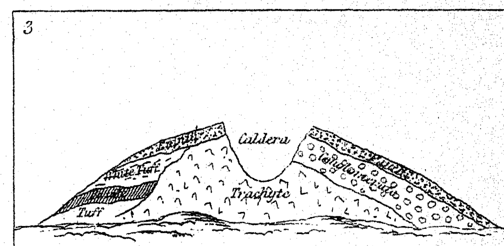
VOLCANOES



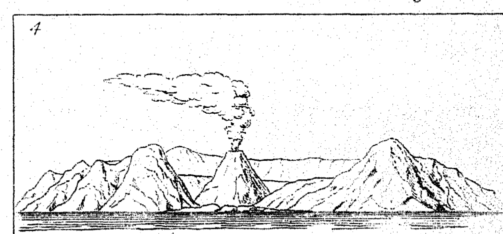
Section of Jorullo and the Malpays.



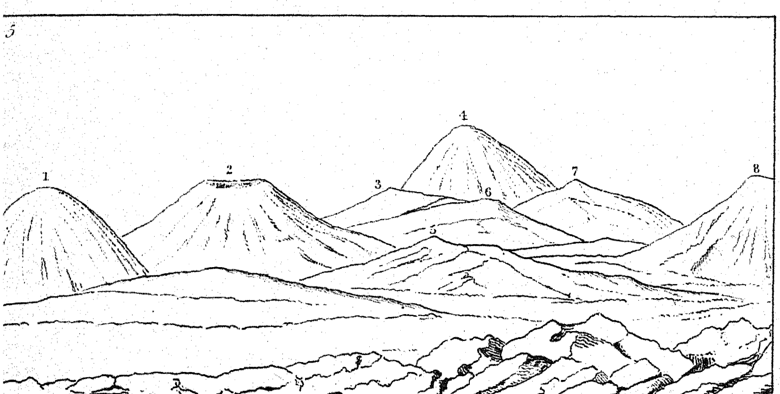
View of the Volcano of Jorullo, Mexico.



Crater of Vandama Island of Gt. Canary.

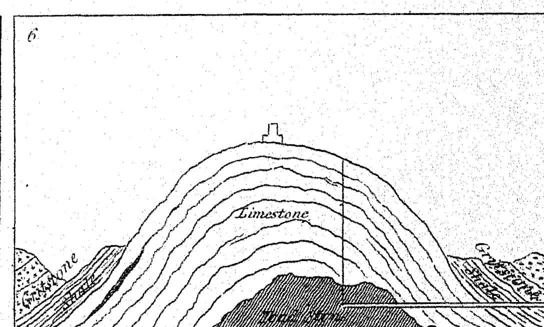


Cone & Crater of Barren Island, Bay of Bengal.

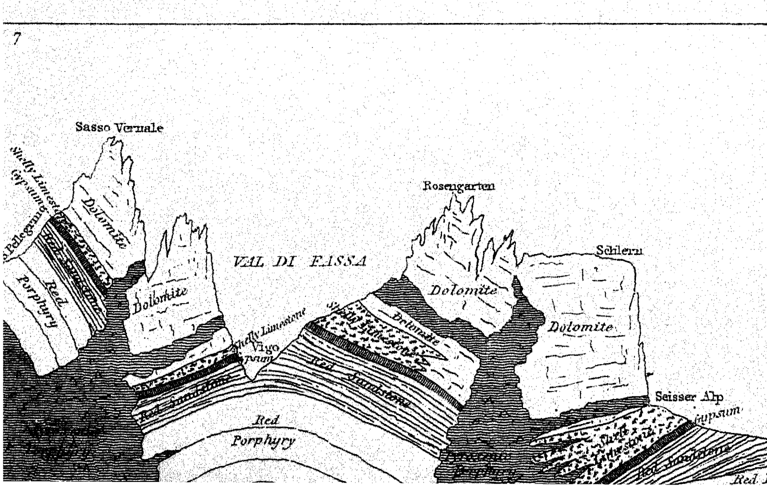


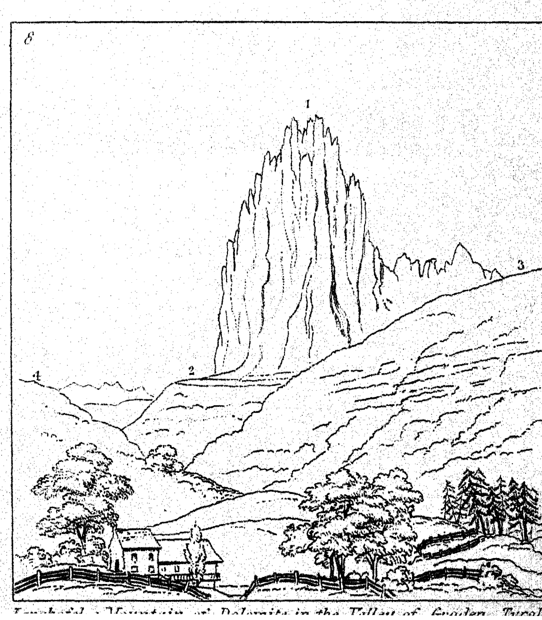
Extinct Volcanoes near Clermont in Auvergne seen from the Puy Chopine.

1. Grand Sarcony. 4. Puy de Dome. 7. Grand Suchet.
2. Puy Pariou. 5. Petit Suchet. 8. Puy de Come.
3. Petit Puy de Dome. 6. Cliersou.



Section of Crich Hill, near Matlock.





Langkofel Mountain of Dolomite in the Valley of Groden, Tyrol.

of 4000 feet, yawns the crater of Kilauea, a fearful gulf, 1500 feet in depth, more than 2 miles in circuit, at the bottom of which is the red-hot lava ever boiling and steaming, as if gathering strength to escape from the abyss, and descend in a fiery deluge upon the surrounding country. Mauna Loa, at other points, sent forth destructive eruptions in 1859 and 1868. The sounds emitted are sometimes heard 1000 miles off, and the ashes from it extend many hundred leagues. The crater of Haleakala ("dwelling of the sun"), on the neighbouring small isle of Mani, is nearly 30 miles in circumference, 10,000 feet high, and forms a pit nearly 3000 feet deep, in which the ridges of nearly twenty old craters arranged concentrically are to be seen.

The preceding details must have convinced the reader that in volcanoes we may find a clue to the discovery of the causes of many of the disturbances of stratification of the mineralogical structure of those rocks which bear unmistakable traces of having been once in a molten state, and of the metamorphism to which they have contributed in the strata immediately overlying them.

Besides the illustrations in the text we refer the student to Plate I., in which he will find a section of Jorullo and the Malpays (fig. 1), and a view of the volcano and its surroundings (fig. 2). The sketches of the crater of Vandama, and the cone and crater of Barren Island (figs. 3, 4), will serve to whet curiosity, so that when we come to treat of volcanic results the other engravings will be found of much value. Few who have heard of the wild grandeur of the mountains of Auvergne—which comprise the most remarkable group of extinct volcanoes in Europe, if not in the world, and on which the unrecorded lava-streams are as finely and freshly marked as if they had but recently been arrested and cooled—will be ungratified by seeing the contour of its cratered summits in fig. 5. The phenomena of magnesian limestone or dolomites (figs. 7 and 8) will recall the researches of Dolomieu, after whom it is named, in the districts represented; while a comparison of these with the limestone hill of Crich (fig. 6), with its irregular interpolation of what is locally called toadstone, will bring us back to the investigation of the igneous phenomena through which such amygdaloids appear in such circumstances, as well as lead us to consider the theories which Dolomieu ripened in Auvergne and Savoy.

ALGEBRA.—CHAPTER II.

MULTIPLICATION—ITS LAWS AND ITS PROCESSES.

Our first notions of multiplication are derived from the operations performed on whole numbers. From these we are led to regard it as a short mode of repeating a quantity as many times as there are units in the multiplier. We find it afterwards necessary to extend the fundamental signification of this term, so as to include within it those cases in which the multiplier is a fraction. The literal symbols used in algebra are necessarily general, denoting fractional quantities as well as whole numbers. We must, on that account, understand our terms in the same enlarged sense. The direction to multiply a by b does not necessarily imply the repetition of a any certain number of times; for b, the multiplier, may be less than 1. It is simply a direction to form with the quantity represented by a, another quantity which shall have the same relation to a that b has to 1. If b be formed by repetitions of 1, that is, supposing it to denote a whole number, then the product of a by b will be formed by repeating a as many times as 1 is repeated to form the number b; and if b be formed of a certain number of equal parts of 1, that is, supposing it to be a proper fraction, then will the product of a by b be formed by taking the same parts of a. The word *times*, which we employ in arithmetical multiplication, must in algebraic calculations be understood to signify either repetition or partition of the multiplicand, according as the multiplier is greater or less than 1, *i.e.* unity.

The things to be most carefully attended to are (1) the *signs*, (2) the *coefficients*, and (3) the *letters*. Like signs give *plus*, unlike ones *minus*. Coefficients are worked with as in arithmetic. Letters, if the same, have their *indices* added; if different, are written down one after the other.

In arithmetic we make use of the sign $\times$ to indicate that the quantities between which it is placed are to be multiplied together. In algebra we occasionally employ it for the same purpose; thus $a \times b$ signifies, in an arithmetical sense, that the quantity a is to be multiplied by the number b; and in an algebraic sense we call $a \times b$ the product of a by b. The same is also sometimes expressed by a point; thus $a.b$ is the same as $a \times b$. But the multiplication of literal quantities is now more simply expressed by writing the letters in succession in the form of a word; thus ab has the same meaning as $a \times b$ and $a.b$, and is more concise. It is therefore most usually adopted.

Let us suppose, at first, that our factors are simple and positive, and that we have given to us $6a \times 4b$. The earliest matter we have here to learn is what to do with our coefficients, if there are any. The coefficient of the product is found by multiplying them into one another, as we do in ordinary arithmetic. The factors given become $6 \times a \times 4 \times b$; these we change into $6 \times 4 \times a \times b$, which yields $24 \times a \times b$. The last item (as we saw in the previous paragraph) yields us ab, and the whole product is $24ab$.

Thus $6abc$ indicates that the quantity abc is taken 6 times, and is the product of the four factors 6, a, b, c, or of the two factors 6 and abc.

The quantity ab is called the product of the factors a, b. To multiply this product ab by another number, c, we write abc, and this we call the product of the factors a, b, c. Multiplication in algebra, like addition and subtraction, is merely an indication of the arithmetical operation which is to be performed upon the numbers represented by the literal quantities. Thus, supposing $a=4$, $b=5$, $c=6$, then

$$ab=4\times 5 \text{ or } 20, \text{ and } abc=4\times 5\times 6 \text{ or } 120.$$

From this we may deduce the general rule for the multiplication of simple algebraic quantities, viz:—

Rule 1. *Write the letters consecutively in the order which is most convenient, without the interposition of any sign, and use the sign* $\times$ *between numerals.* The alphabetical arrangement of the letters is usually preferred.

Thus, $a \times b \times c \times d$ is written $abcd$, and every such expression as $abcd$, formed of several letters written in immediate succession to one another, designates the product of the numbers represented by these letters.

Let it be required to multiply a^3b^2c by a^2bc. We know that, in point of fact, a^3b^2c is in reality equal to $aaabbc$, and a^2bc equal to $aabc$, and therefore that we are asked to multiply $aaabbc$ into $aabc$, or interverting the factors, that we have $aaaaa \times bbb \times cc$, so that the product is $a^5b^3c^2$.

To indicate a multiplication in which there are several simple products having coefficients we might apply the rule given above without error. Thus, $4ab \times 3cd \times 5mq$ might be written $4ab3cd5mq$. But as multiplications may be made in any order without affecting the numerical result of the operation, we profit by this circumstance to collect, for the sake of simplicity and symmetry of expression, all the numerical coefficients together by the arithmetical rule. Thus, instead of writing $4ab3cd5mq$, we write $4.3.5abcdmq$ or $60abcdmq$. This is more concise and convenient. It is, however, only a conventional convenience; the one form of expression is identical with the other in signification.

To multiply simple quantities therefore presents no difficulty if we observe the following—

Rule 2. *Multiply the coefficients of the multiplier and the multiplicand together; next add the exponents which affect the same letters, and then write the different letters one after another, usually in the order of the alphabet.*

Multiply $3ab^2$ by $7bc^2$. (1) $3\times 7=21$; (2) $ab^2\times bc^2=ab^3c^2$, and hence Ans. $21ab^3c^2$.
Multiply $12a^4b^2c$ by $3a^3bm^2$. Ans. $36a^7b^3cm^2$.
Multiply $7ab^2$ by $12a^2bc$. Ans. $84a^3b^3c$.

Notice in working such sums (1) that when no *index* is expressed the index 1 is understood; thus $a=a^1$; and (2) the sum of the indices indicates the multiplication of indexed quantities; thus $a^2\times a^3=a^5$.

Observe, also, that when the signs of both quantities are *alike* they result in $+$; but when *unlike* in $-$; as

$$+a\times+b=+ab;\quad -a\times-b=+ab;\quad +a\times-b=-ab;\quad -a\times+b=-ab.$$

This is easily seen; thus—

$$\begin{array}{cccc} +a & -a & +a & -a \\ +b & -b & -b & +b \\ \hline +ab & +ab & -ab & -ab \end{array}$$

To multiply is to add as many times as there are units in the multiplier.

If, then, the quantities to be multiplied have coefficients, these must be multiplied together as in common arithmetic, and the literal product must be written consecutively, as directed in Rule 1 (p. 249). The following are examples:—

$$2ax\times4bb\times5ax=2\times4\times5axbbax=40aabbxx.$$
$$\tfrac{1}{2}px\times2pq\times7ax=\tfrac{1}{2}\times2\times7pxpqax=7appqxx.$$
$$\tfrac{1}{3}pq\times3p\times3q=3ppqq.\quad \tfrac{1}{7}xy\times\tfrac{3}{4}yz\times\tfrac{1}{3}xz=\tfrac{1}{28}xxyyzz.$$
$$\tfrac{7}{8}an\times\tfrac{5}{7}mq\times\tfrac{3}{4}pr\times am=\tfrac{15}{32}aammnpqr.$$

The multiplication of complex quantities is resolvable into the same operation as that explained and exemplified in arithmetic; when the quantities to be multiplied together consist of several parts, every part of the one must be multiplied by every part of the other, and the sum of all the partial products must be taken as the total product of the two quantities. In algebra these partial products can be found by the rules given above, although the process presents a peculiarity which is not found in the arithmetical operation. For instance, let it, in the first place, be required to multiply $a+b$ by c; that is, to find c times $a+b$. The product of a by c is ac, and that of b by c is bc; but the product of the sum of a and b by c is manifestly the sum of the product ac and bc; that is, $ac+bc$. Hence c times $(a+b)=c(a+b)=ac+bc$.

Again, let it be required to multiply $a-b$ by c; that is, to find c times $a-b$. The partial products, as before, are ac and bc; but since a is greater than $a-b$ by the quantity b, it is clear that c times a—that is, ac—is greater than c times $a-b$ by the quantity bc, consequently bc must be subtracted from ac, which gives $ac-bc$ for the product required. Hence c times $(a-b)=c\,(a-b)=ac-bc$.

The same reasoning holds good whatever be the number of terms in the multiplicand. These two cases, therefore, furnish the rule for the multiplication of a complex quantity by a quantity of one term, namely, *Write the multiplier into every term of the multiplicand.* In practice we commonly multiply from left to right, as in the following example:—

$$\begin{array}{l} \text{Multiply } ab+\ c\ -2d\ +3m\ -4n\ -qx \\ \quad\text{by } 2z \\ \hline \text{Product:—}2abz+2cz-4dz+6mz-8nz-2qxz \end{array}$$

The use of brackets in this rule is shown in the undergiven statements.

$$2ax\,(a+b-c+1)=2aax+2abx-2acx+2ax.$$
$$\tfrac{1}{2}xy\,(x-z)+z\,(1-z)=\tfrac{1}{2}xxy-\tfrac{1}{2}xy+z-zz.$$
$$ab\,(x-1)-bc\,(1-x)-cd\,(1+x)=$$
$$abx-ab-bc+bcx-cd-cdx.$$
$$m\{n\,(a+b-c-d+1)+pp\}=$$
$$amn+bmn-cmn-dmn+mn+mpp.$$

When the multiplier is composed of several terms, we have the following cases:—

1. Let it be required to multiply $a+b$ by $c+d$. Here $a+b$ is to be taken $c+d$ times—that is, c times $+d$ times; now c times $a+b$ is $ac+bc$, and d times $a+b$ is $ad+bd$; but $c+d$ times $a+b$ must manifestly be the sum of these partial products; that is, $(ac+bc)+(ad+bd)$, which, taking away the brackets, becomes $ac+bc+ad+bd$.

2. Let it be required to multiply $a-b$ by $c+d$. Here c times $a-b$ by c is $ac-bc$, and d times $a-b$ is $ad-bd$; and the sum of these products is $(ab-bc)+(ad-bd)$; that is, taking away the brackets, $ab-bc+ad-bd$.

From these and similar examples we deduce the following:—

Rule 3. *The multiplier being the sum of several terms, the total product sought is composed of the sum of the partial products of the multiplicand by every term of the multiplier.*

Suppose now that the multiplier contains a subtractive term, it is clear that the products formed by that term must be taken with a contrary sign to that which they have by the preceding rule. Treating this condition as above, let us inquire—

1. What is the product of $a+b$ by $c-d$? This question is evidently the following: What is c times $(a+b)-d$ times $(a+b)$? Now c times $a+b$ is $ac+bc$, and d times $a+b$ is $ad+bd$; consequently,

$$c \text{ times } (a+b)-d \text{ times } (a+b)=(ac+bc)-(ad+bd);$$
$$\text{that is, } (c-d) \text{ times } (a+b)=(ac+bc)-(ad+bd),$$
$$\text{or } (a+b)\times(c-d)=ac+bc-ad-bd,$$

and this last is the product sought, having the brackets struck out.

2. What is $a-b$ multiplied by $c-d$? The answer to this question must obviously depend upon the same reasoning as that employed in finding the answer to the preceding. We have in the first place—

$$c \text{ times } (a-b)-d \text{ times } (a-b)=(ac-bc)-(ad-bd);$$
$$\text{that is, } (a-b)\times(c-d)=ac-bc-ad+bd$$

by taking away the brackets of the product.

From these and other like examples we gain

Rule 4. *When a term of a multiplier is preceded by the sign $-$, every partial product formed by that term will have the contrary sign to that of the corresponding term of the multiplicand.*

The preceding operations, and the rules to which they lead, are directly deducible from the principles exemplified under Rules 1 and 2.

Thus putting $c+d=m$, then $(a+b)\times(c+d)$ becomes $(a+b)\,m=am+bm$; and putting for m its value we have

$$am+bm=a\,(c+d)+b\,(c+d)=ac+ad+bc+bd.$$

Again, putting $c-d=n$, then $(a-b)\times(c-d)$ becomes $(a-b)\,n=an-bn$; and putting for n its value we have

$$an-bn=a\,(c-d)-b\,(c-d)=ac-ad-bc+bd$$

The multiplication of all complex quantities may be reduced to this last case by representing the sum of the *positive* terms in each of the two factors by a and c respectively, and that of the negative terms similarly by b and d; it then only remains to assign the values of the partial products ac, bc, ad, bd.

To render this plain, let it be required to multiply $5x-3y+2z$ by $xy-2z$. The multiplicand may obviously be written $(5x+2z)-3y$. Let $5x+2z=a$ and $3y=b$, then $5x-3y+2z=a-b$; similarly put $xy=c$ and $2z=d$, then $xy-2z=c-d$. The product of $a-b$ by $c-d$ is (as was shown in Rule 3, Ex. 2)

$$ac-ad-bc+bd;$$

$$\begin{aligned} \text{but } ac&=(5x+2z)\times xy=5xxy+2xyz,\\ ad&=(5x+2z)\times 2z=10xz+4zz,\\ bc&=3y\times xy=3xyy, \quad\text{and } bd=3y\times2z=6yz.\\ \therefore ac-ad-bc+bd&=5xxy+2xyz-(10xz+4zz)-3xyy+6yz\\ &=5xxy+2xyz-10xz-4zz-3xyy+6yz, \end{aligned}$$

which is the product of $5x-3y+2z$ by $xy-2z$.

Observing the results obtained in these cases, we find that every term of the multiplicand is multiplied by every term of the multiplier, and that where the terms so multiplied have both the same sign, that is, both $+$ or both $-$, their product has the sign $+$, and where they have different signs, that is $+$ and $-$, or $-$ and $+$, their products take the sign $-$. We see therefore that they establish the following general rule for the multiplication of complex algebraic quantities together:—

Rule 5. *Multiply every term of the multiplicand by every term of the multiplier (according to the rule for simple quantities), and put $+$ before the products of terms which have the* SAME *sign, and $-$ before the products of terms which have* DIFFERENT *signs.*

The first terms, which have usually no sign prefixed, must be considered to have $+$, and also any term having no co-

efficient or exponent expressed is understood to have unity (*i.e.* 1) for each. Hence also we learn that (1) if *all* the factors are plus (+), the product will be plus; (2) if an *even* number of factors are minus (−), the product will be plus; (3) if an *odd* number of factors are minus, the product will be plus.

The following example not only illustrates this rule, but shows the common mode of arranging the operation to facilitate reduction when the partial products contain like terms.

$$\begin{array}{ll} \text{Multiply} & 2a+bc-2bb \\ \text{By} & 2a+bc-2bb \end{array}$$

$$\begin{array}{ll} \text{P. from } +2a & 4aa+2abc-4abb \\ \text{"}\quad +bc & \qquad 2abc \qquad\quad +qbcc-2bbbc \\ \text{"}\quad -2bb & \qquad\qquad -4abb \qquad -2bbbc+4bbbb \end{array}$$

Total product, $4aa+4abc-8abb+bbcc-4bbbc+4bbbb$

It will be observed in writing down the partial products that we have arranged all the like terms under each other; this enables us to perform the reductions with greater readiness. These reductions being effected in taking the sum of the partial products, the result is the product sought.

The student who carefully goes over the following example point by point until he sees how each operation has been done, and how each product has come out as a result of the special process performed for the purpose, will find himself amply repaid for his exercise of patient perseverance and assiduous thoughtfulness.

Multiplicands, $5a^3-7a^2b+3ab^2+4b^3$
Multipliers, $3a^2-8ab-b^2$

$$\text{Partial products,}\left\{\begin{array}{l} 15a^5-21a^4b+9a^3b^2 \quad +12a^2b^3 \\ \qquad -40a^4b+56a^3b^2-24a^2b^3-32ab^4 \\ \qquad\qquad -5a^3b^2 \quad +7a^2b^3 \quad -3ab^4 \quad -4b^5 \end{array}\right.$$

Total, $15a^5-61a^4b-60a^3b^2-5a^2b^3 \quad -35ab^4-4b^5$

After having studied the foregoing example as advised, and seen into it, let the student try the following three cases, viz.:—

$4a\ x^2+8axy+4y^2 \times 2ax+2y.$
Ans. $8a^3x^3+24aax^2y+24axy^2+8y^3.$

$9a^2-3ab+b^2-6a-2b+4 \times 3a+b+2.$
Ans. $27a^3+b^3+8-18ab.$

$a^2+b^2+c^2-ab-ac-bc \times a+b+c.$
Ans. $a^3+b^3+c^3-3abc.$

When we wish simply to indicate the multiplication of two complex expressions, we inclose each of the factors between brackets, and write these in succession without the interposition of any sign. For instance, the expression $(a-b)$ $(c-d)$ is the same as $(a-b)\times(c-d)$, and indicates the product of $a-b$ by $c-d$, as before shown. Some of the old algebraists put the factors under lines as below—

$$\overline{a-b}+\overline{c}\times d \text{ and } \overline{a-b)}\ \ \overline{c-d)};$$

but this notation is neither so neat nor so exact as the other, and has therefore been abandoned. We shall often have occasion to make use of the brackets to denote the multiplication of quantities, and therefore shall give a few examples which the student is expected to work out and verify:—

Multiplicand.	Multiplier.	Product.
$ax+bx+c$	$a-b$	$aax-bbx+ac-bc$
$aa+2ab+bb$	$a-\frac{1}{2}b$	$aaa+\frac{3}{2}aab-\frac{1}{2}bbb$
$xx-\frac{1}{2}x+\frac{2}{3}$	$\frac{1}{3}x+2$	$\frac{1}{3}xxx+\frac{11}{6}xx+\frac{7}{9}x+\frac{4}{3}$

Multiply $1-x+xx-xxx$ by $1+x$. Ans. $1-xxxx$.

$$(xx+2\,xy+yy)\,(xx-2\,x+yy)=xxxx-2xxyy+yyyy.$$
$$(xx-\tfrac{3}{4}x+1)\,(xx-\tfrac{1}{2}x)=xxxx-\tfrac{5}{4}xxx+\tfrac{11}{8}xx-\tfrac{1}{2}x.$$

When the same quantity is multiplied into itself any number of times the result is called a *power* of that quantity.

Thus x multiplied by x, or xx, is called the second power of x
xx " " x, or xxx, " the third " of x
xxx " " x, or $xxxx$, " the fourth " of x

and so on; and x when compared with xx, xxx, &c., is called the first power of x. The second and third powers are called the *square* and *cube*, from certain relations between them and the geometrical square and cube of a line of x units.

The following three *formulæ* connected with this subject lead to results which are of frequent use, and therefore ought to be remembered.

1. What is xx when $x=a+b$? This question is equivalent to the following:—What is the square or second power of $a+b$? For, on the assumption $x=a+b$, we have

$$\begin{aligned} xx=(a+b)\,(a+b) &= aa+2\ ab+bb \\ &= aa+bb+2\ ab=a^2+2ab+b^2 \end{aligned}$$

that is, (1) *The square or second power of a quantity composed of two parts,* a *and* b, *is composed of the sum of the squares of these parts* INCREASED *by twice their product.*

This may be exhibited in actual process.

$$\begin{array}{l} a+b \\ a+b \\ \hline a^2+ab \\ \quad +ab+b^2 \\ \hline a^2+2ab+b^2 \end{array}$$

To make this clear by an illustration in whole numbers, let the whole number 27 be resolved into two parts, 20 and 7; then the squares of the parts are 400 and 49, and double their product is 280, then according to the theorem,

The square of $27=400+49+280=729$.

The converse is also true.

2. Let x in xx be $a-b$, then we have

$$\begin{aligned} xx=(a-b)\,(a-b) &= aa-2\ ab+bb \\ &= aa+bb-2\ ab=a^2-2ab+b^2. \end{aligned}$$

Exhibited thus:—

$$\begin{array}{l} a-b \\ a-b \\ \hline a^2-ab \\ \quad -ab+b^2 \\ \hline a^2-2\ ab+b^2 \end{array}$$

that is, (2) *The square or second power of the difference of two quantities,* a *and* b, *is the sum of their squares* DIMINISHED *by twice their product.*

Let the two numbers taken in this case be 100 and 5; their squares are 10000 and 25, and twice their product is 1000; therefore

The square of $100-5$ or $95=10000+25-1000=9025$

3. What is xy when $x=a+b$ and $y=a-b$?
Answer, $xy=(a+b)\,(a-b)=aa-bb$; *i.e.* a^2-b^2.

This is shown in the process below:—

$$\begin{array}{l} a+b \\ a-b \\ \hline a^2+ab \\ \quad -ab-b^2 \\ \hline a^2 \qquad -b^2 \end{array}$$

from which we find that, (3) *if the* SUM *of two numbers be multiplied by their* DIFFERENCE, *the product is the difference of the squares of the numbers.*

Let us take for a numerical example 17, the sum of the numbers 10 and 7; multiplying this by the difference $10-7$, or 3, we have the product 17×3, or 51, which is equal to the difference between 100, or the square of 10, and 49, or the square of 7.

It is highly important to have these rules, and the results of the foregoing formulæ, well grounded in the memory, and that the formulæ themselves should be quite familiar.

The following are applications of these formulæ:—

Square of $4ax+2vy=16aaxx+16avxy+4vvyy$
" " $2a\,(x-y)=4aa\,(xx-2xy+yy)$
$=4aaxx-8aaxy+4aayy$
" " $(a+b)+c=(a+b)\,(a+b)\ +2\ c\,(a+b)\ +cc$
$=aa+bb+cc+2ab-2bc+2ac$
" " $(a+b)-c=aa+bb+cc-2ab-2ac+2bc$

$$(\tfrac{1}{3}\ ax+\tfrac{1}{2}\ ay)\,(\tfrac{1}{3}\ ax-\tfrac{1}{2}\ ay)\ =\ \tfrac{1}{9}aaxx-\tfrac{1}{4}aayy)$$

What is $ax-bx$ when $x=a-b$? Ans. Square of $a-b$.

What does $(a+x)(a-x)$ become when x is changed into $x+h$? Ans. $aa-(x+h)(x+h)=aa-xx-2\,xh-hh$.

Show that $(a-b)(a+b)-(b-a)(b+a)=2\,(a+b)(a-b)$.

The student should accustom himself to write out such developments as the preceding at *sight;* they are of very frequent occurrence, and a little practice is all that is necessary to enable him to accomplish the process mentally. The following theorems will afford him some further practice:

If a and b be two numbers of which a is the greater, and if S be the square of their sum, D the square of their difference, and P the product of their sum and difference, show that

$$S+D=2\,(aa+bb). \qquad S-D=4ab.$$
$$S+P=2\,(aa+ab). \qquad S-P=2(ab+bb).$$
$$D+P=2\,(aa-ab). \qquad P-D=2(ab-bb).$$
$$S+D+P=3aa+bb.$$

It will be well to verify these results by the substitution of particular numbers for a and b.

The foregoing formulæ may be made use of when any two quantities to be multiplied together consist of some which differ only in sign, by taking as a all those terms which are found with their signs unaltered in each of the given quantities, and as b all the other quantities; for example, take $a^2+ax+x^2\times a^2-ax-x^2$. This equals $\{(a^2-x^2)+ax)\}\times\{(a^2-x^2)-ax\}$, and this is equal to $(a^2-x^2)^2-a^2x^2$, which again equals $a^4-2\,a^2x^2+x^4-a^2x^2$; and then we reduce to the answer, $a^4-3\,a^2x^2+x^4$.

See also how the following examples substantiate these rules:—

$(3y-4x)(3y+4x)$ regarded as represented in form of result by $(a-b)(a+b)$, we know they will yield as their product $9y^2-16x^2$. $(x-2y)^2$ also yields as product $x^2-4xy+4y^2$.

It may aid the student to understand what he will often see in algebraic examples if he is told that when the degree of a power is indifferent or indeterminate, the letter m is very generally used as an exponent; thus, a^m signifies a raised to any given power which m, by convention, shall denote. When a polynomial is to be raised to a power it is inclosed in parentheses, and outside of the last of the parentheses the exponent is placed; thus $(a+b-c)^3$ means the cube of $a+b-c$.

ASTRONOMY.—CHAPTER III.

THE PLANETS—NAMES OF THE PLANETS—THEIR MOTION—KEPLER'S LAWS—ELEMENTS OF A PLANET'S ORBIT—BODE'S LAW—ELEMENTS OF SUPPOSED PLANET VULCAN;—MERCURY—PHASES—DETERMINATION OF ITS MASS—ANCIENT OBSERVATIONS OF THE PLANET;—VENUS—PERIOD—PHASES—BRILLIANCY—SPOTS—AXIAL ROTATION—ATMOSPHERE—EMPLOYMENT OF VENUS FOR NAUTICAL OBSERVATIONS;—THE EARTH—PERIOD—MEASUREMENTS OF MASS—THE ECLIPTIC—THE EQUINOXES—THE SOLSTICES—DIMINUTION OF OBLIQUITY OF ECLIPTIC—ECCENTRICITY OF ORBIT—MOTION OF APSIDES—TABLES OF DURATION OF DAY AND NIGHT—RECENT VALUES OF EARTH'S MASS.

Around the great mass of the sun, as a centre, various bodies, called planets, which do not give out light like the sun, and are only rendered visible by reflecting the sun's light, revolve at greater or less distances. The *inferior* planets, or those whose orbits or paths round the sun (as shown in Plate II.) are within that of the earth, are named Mercury and Venus; the *superior* planets, or those whose orbits are beyond that of the earth, are Mars, Jupiter, Saturn, Uranus, and Neptune. The four *minor* or smaller planets are Mercury, Venus, the Earth, and Mars. If the planets were viewed from the sun they all would appear to revolve round that centre in the order of the zodiacal signs; but as they are viewed by us from the earth, which is one of their number and is itself in motion, they appear to travel in a capricious manner, whence they were originally called *planets* or wanderers. The inferior and superior planets also differ, the one class from the other, in their apparent movements. The inferior planets are never seen in those parts of the heavens which are in opposition to the sun; that is, they are never on the *meridian* at midnight, being always within a short angular distance of the sun, east or west, as the case may be. The *meridian* of a place is a great circle passing through the pole of the heavens, as well as the zenith of the place of observation. Twice in every revolution an inferior planet is said to be in *conjunction* with the sun. When it comes between the earth and the sun it is in *inferior conjunction;* when the sun intervenes between the earth and the planet it is in *superior conjunction.* When it attains its greatest distance from the sun, east or west, as viewed from the earth, it is said to be at its *greatest elongation*, east or west, as the case may be. In the former case the planet is an *evening star*, in the latter a *morning star*. Although a planet always moves in the order of the signs of the zodiac—that is, in the direction of the sun's apparent annual path among the stars—there are periods when it appears *stationary*, and sometimes its motion appears *retrograde* or reversed. These peculiarities are only apparent, and not real, and are due to the fact that the earth has simultaneously a motion of its own in its orbit. The same also obtains with the superior planets. It sometimes, though very rarely, occurs that an inferior planet, when in inferior conjunction, passes directly between the earth and the sun, and is seen projected on the disc of the latter, which it traverses from east to west; this phenomenon is termed a *transit* (Lat. *transire*, to go across).

A superior planet, one of those outside the earth's orbit, can have any angular distance from the sun not exceeding 180°. After starting from conjunction with the sun it successively reaches its eastern quadrature, or angular distance of 90°, and its opposition at 180°. It then in succession comes to its western quadrature, 270° from the sun, *reckoned in the direction of its motion*, but only 90° if reckoned in the other direction; and finally, another 90° brings it once more into conjunction. Consequently its greatest angular distance from the sun is 180°, as it then begins to approach the sun again on the other side.

There are certain characteristics common to all the planets: they move in the same invariable direction round the sun, in a course, as viewed from the north side of the ecliptic or plane of the earth's orbit, which is contrary to the motion of the hands of a watch. Their orbits or paths round the sun are in the forms of ellipses or ovals, not greatly differing from circles. Their orbits are also more or less inclined to the ecliptic, and intersect it in two points, termed the *nodes*, one half of the orbit being north and the other south of the earth's path. They all rotate on their axes; hence they will each have, like the earth, alternation of day and night, the days being of various lengths. Under the influence of the sun's attraction their velocity is greatest at those parts of their orbit which lie nearest the sun, called by astronomers *perihelion*, and least at the opposite part, that most distant from the sun, called *aphelion*. This difference of velocity is enormously great in comets, owing to the vast eccentricity of their orbits (Plate II.) The velocity of Donati's comet, which appeared in October, 1858, at perihelion is 127,000 miles per hour, but at aphelion only 480 miles. Kepler deduced from a long series of observations of the planet Mars certain definite laws relative to the motions of planets (see fig. 2, Plate V.):—

(1) They move in ellipses, having the sun in one of the foci.

(2) The *radius vector* (a line drawn from the planet to the sun) of each planet describes or passes over equal areas in equal times.

(3) The squares of the periodic times of the planets are proportional to the cubes of their mean distances from the sun.

These laws are general for all the planets and all their satellites.

The orbit of a planet, with reference to its form, magnitude, and position, is determined by the following *elements:*—

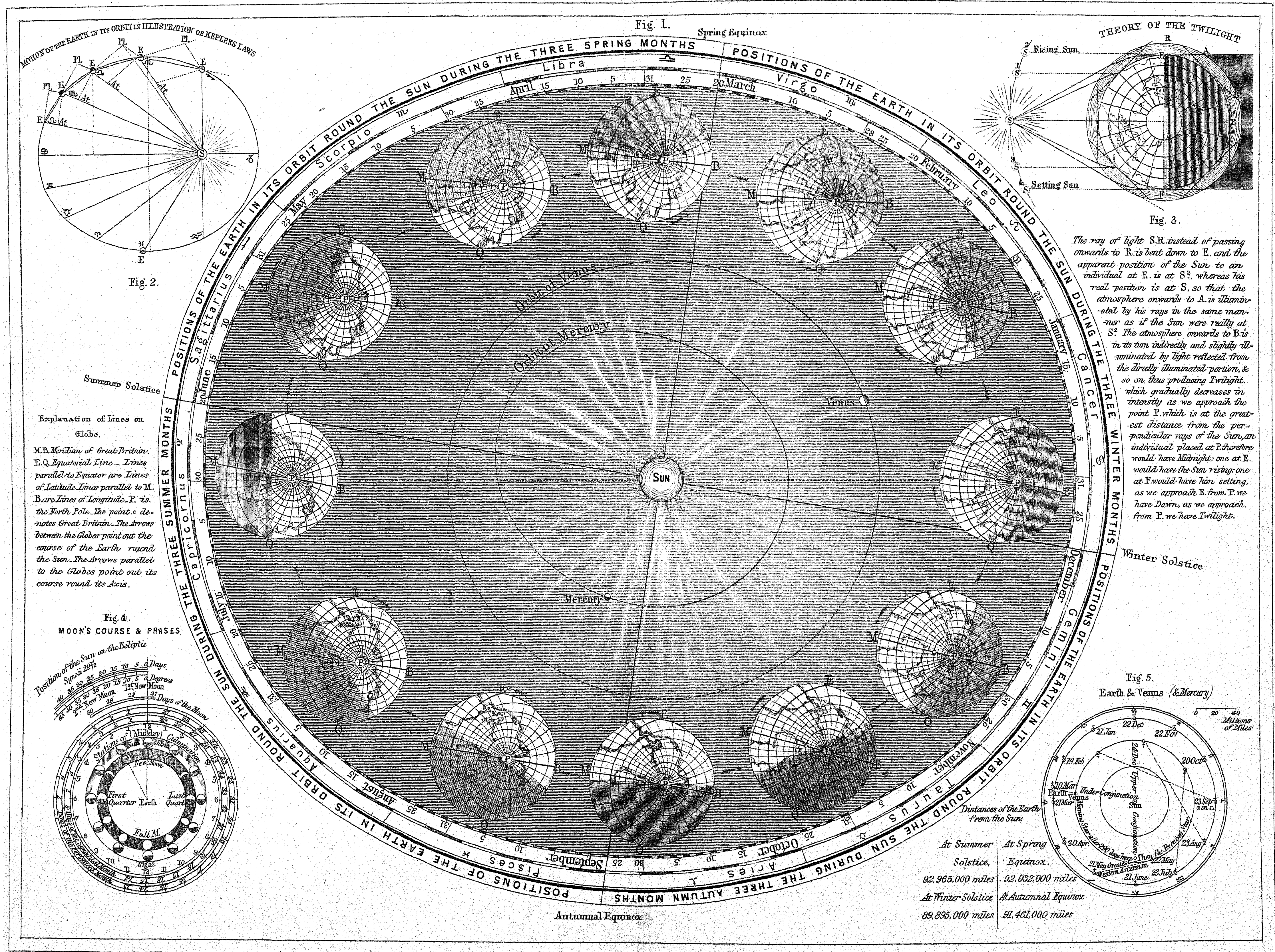
(1) The longitude of its perihelion, denoted by the symbol ϖ.

(2) The longitude of the ascending node of the planet's orbit, as viewed from the sun, ☊.

(3) The inclination of the plane of the orbit with the ecliptic, ι.

ASTRONOMY.

ANNUAL REVOLUTION OF THE EARTH ROUND THE SUN.



(4) The eccentricity, ϵ, sometimes expressed by the angle ϕ, of which ϵ is the natural sine.

(5) The semi axis-major, or mean distance, a.

(6) Its periodic time, calculated from No. 5 by Kepler's third law.

(7) Its mean longitude.

The third law of Kepler involves a remarkable coincidence, namely—if the square of the periodic times of the planets be divided by the cubes of their mean distances from the sun, the quotients obtained are the same for all the planets.

PLANET.	a	p	$\frac{p^2}{a^3}$
Vulcan,	0·143	19·7	132716
Mercury,	0·38710	87·969	133421
Venus	0·72333	224·701	133413
Earth,	1·00000	365·256	133408
Mars,	1·52369	686·979	133410
Ceres,	2·77692	1679·855	132210
Jupiter,	5·20277	4332·585	133294
Saturn,	9·53858	10759·220	133375
Uranus,	19·18239	30686·821	133422
Neptune,	30·03627	60126·722	133413

The want of exact uniformity in the fourth column is due to inexactness in the observations on which the calculations are based, and also to the *perturbations* which the planets mutually exercise on each other's orbits. This law also holds good for their *satellites*, smaller bodies, like our moon, which revolve round several of then. One example, the satellites of Saturn, may be given.

SATELLITES OF SATURN.

NAME.	a.	p.	$\frac{p^2}{a^3}$
Mimas,	3·36	0·94	23295
Enceladus,	4·31	1·37	23443
Tethys,	5·34	1·89	23458
Dione,	6·84	2·74	23460
Rhea,	9·55	4·52	23457
Titan,	22·14	15·95	23442
Hyperion,	26·86	21·30	23412
Japetus,	64·54	79·33	23409

In order to place the coincidences in a stronger light, the decimal point has been omitted in the fourth column of the two tables.

The laws enunciated by Kepler are the foundation of all planetary astronomy, and it was from them that Newton deduced his theory of gravitation.

The comparative magnitudes of the planets and their relative distances from the sun are indicated on Plate II., and also the relative apparent size of the sun, as viewed from the different planets.

Bode of Berlin published, in 1778, the following "law" of the numerical relations existing between the distances of the planets.

Taking the numbers 0, 3, 6, 12, 24, 48, 96, 192, 384, each of which, except the second, is double the preceding, and adding 4 to each of these, the series becomes 4, 7, 10, 16, 28, 52, 100, 196, 388, which numbers approximately represent the distances of the planets from the sun expressed in radii of the earth's orbit. Bode having examined these relations, and observing the void between 16 and 52 (Ceres and the minor planets were at that date undiscovered), predicted the discovery at some future date of new planets. The discovery of Ceres and the asteroids has fulfilled this prediction. Bode's law may be stated as follows:—That the interval between the orbits of any two planets is about twice as great as the *inferior* interval, and only half the *superior* one.

Taking the interior group of planets, Mercury, Venus, the Earth, and Mars, and the exterior group, Jupiter, Saturn, Uranus, and Neptune, they will be found to differ in the following respects:—

1. The interior planets, with the exception of the Earth, and probably Mars, are not, so far as is at present ascertained, attended by any satellites, while the exterior planets all have satellites.

2. The average density of the interior planets greatly exceeds that of the exterior, the approximate ratio being as 5 to 1.

3. The mean duration of the axial rotations, or mean length of the day, of the interior planets, is much longer than that of the exterior group. In the former case the average is 23 hours 58 minutes, in the latter only 10 hours 12 minutes.

In examining the theory of the orbit of Mercury, the nearest planet to the sun at present known, Le Verrier, the French astronomer, was led to the conclusion that a certain error in the assumed motion of the perihelion could only be explained by the mass of Venus being at least one-tenth greater than was generally imagined, or if this was not so, that there must exist, at present undetected, some unknown planet or planets, situated between Mercury and the sun capable of producing a disturbing action. No opinion, however, was offered by Le Verrier; he simply placed these hypotheses before the scientific world in the autumn of 1859. On these views being made public, it was stated by M. Lescarbault, that on 26th March of that year he had observed an object pass across the sun's disc which he thought might be a new planet. From the rough observations made Le Verrier was able to calculate approximate elements for the supposed new planet Vulcan, and in March or April, 1860, it was anticipated that the planet would again cross the solar disc. No trace of it was then obtained. This, however, proves nothing, and by many the existence of this planet is regarded as certain. On examining the application of Kepler's third law, a result is shown sufficiently consistent with the results in the cases of the other planets to arrest attention. Additional evidence can now be adduced as to the reality of the discovery, and Le Verrier has recently announced that the orbit of Mercury is perturbed to an extent which renders it necessary to augment the movement of the perihelion by 31 seconds in a century; and that there is, without doubt, in the neighbourhood of Mercury, and between that planet and the sun, matter hitherto unknown. Although with some sceptical minds it is a fashion to deny the existence of Vulcan—and, so far, telescopic research and scrutiny of the solar disc at certain dates have been unsuccessful in tracing the planet—it is scarcely prudent, under the circumstances, to speak definitely on the subject. Its existence is left to be fully demonstrated at some future time. From Lescarbault's rough observations Le Verrier calculated the annexed approximate elements.

ELEMENTS OF PLANET VULCAN.

Longitude of ascending node,	=12° 59′
Inclination of orbit,	=12° 10′
Semi axis-major (⊕=1),	= 0·143
Daily heliocentric motion,	=18° 16′
Period,	=19 days 17 hours
Mean distance,	=13,082,000 miles
Apparent diameter of ☉ from Vulcan,	= 3° 36′
" " " (⊕=1)	= 6·79
Greatest possible elongation,	= 8°

THE MINOR PLANETS.

MERCURY. ☿

Mercury is the nearest known planet to the sun, round which it revolves in a period of 87 days 23 hours 15 minutes 43·91 seconds, at a mean distance of 35,392,000 miles. As the eccentricity of its orbit amounts to 0·205, the distance may extend to 42,665,000 miles, or contract to 28,119,000 miles. The apparent diameter of Mercury varies between 4·5 seconds in superior conjunction, and 12·9 seconds in inferior conjunction; at its greatest elongation it amounts to about 7 seconds. The real diameter of the planet is 3050 miles. The difference between the polar and equatorial

diameter, as determined by Dawes in 1848, is one-twenty-ninth. Mercury, like our moon, exhibits *phases*. At its greatest elongation half its disc is illuminated; as it approaches superior conjunction the breadth of the illuminated part increases, and its form becomes *gibbous*—that is, the illuminated portion is greater than a semicircle and less than a circle; and when in superior conjunction, circular: at this point the planet is lost in the solar rays, and is invisible. On emerging the gibbosity is on the opposite side, and diminishes gradually till the planet arrives at its greatest elongation on the opposite side, when it again appears like a half moon, and becomes more and more crescented as it approaches the inferior conjunction.

Observations on the physical appearance of Mercury are obtained with extreme difficulty, owing to its proximity to the sun. As the greatest possible elongation of the planet does not exceed 27° 45′, it can never be seen free from strong sunlight, under which conditions it may be viewed with the naked eye during an hour and a half or so after sunset in the spring (east elongation), and before sunrise in the autumn (west elongation), shining with a pale rosy hue. The planet may frequently be found in the daytime with the aid of a good telescope.

The disc of Mercury has not received much attention from astronomers, and the main sources of information are from the observations of Schröter and of Sir W. Herschel. The former observer obtained what he believed to be positive evidence of the existence of high mountains on the planet's surface; one in particular in the southern hemisphere, which has been set down at 10·7 miles in height—an elevation far exceeding that of any mountain on the earth. Mercury is not known to be possessed of an atmosphere; hitherto, at least one has not been detected. So far also as is known Mercury is not attended by any satellite, and the determination of its mass is a difficult and uncertain problem. The small comet of Encke, however, has furnished the means of making some calculations based on the disturbances effected in the motion of this comet by the action of Mercury, and it has been calculated by Encke that the mass of the planet is $\frac{1}{4865751}$ that of the sun. Le Verrier gives $\frac{1}{3000000}$, and Mädler $\frac{1}{4870333}$. The most ancient observation of this planet known is 265 years before the Christian era, and observations of Mercury by Chinese astronomers are in existence as far back as the year 118 A.D. Copernicus never succeeded in detecting it—a failure due probably to the vapours prevailing near the horizon on the banks of the Vistula, where the great philosopher lived.

VENUS. ♀

After Mercury, the planet next in order of distance from the sun is Venus, which performs its orbit round the sun in 224 days 16 hours 49 minutes 8 seconds, at a mean distance of 66,131,000 miles. The eccentricity of the orbit of Venus is only 0·006, the distances from the sun are therefore only 66,585,000 and 65,677,000 miles in aphelion and perihelion respectively. No other planet, major or minor, has an eccentricity so small. The apparent diameter of Venus varies between 9·7 seconds in superior and 66·5 seconds in inferior conjunction. At its greatest elongation its apparent diameter is about 25 seconds. From a series of observations made by various astronomers, and by Tennant in 1874 during the transit, the real diameter of the planet is about 7500 miles, which is very nearly the same as that of the earth. The existence of any compression at the poles is at present undetermined, owing to the planet's diameter at superior conjunction being so small. Should it exist, it must be very insignificant. Venus exhibits *phases* in every way identical with those of Mercury. As the planet is never further removed from the sun than 47° 15′, it is always under the influence more or less of twilight. Nevertheless it is difficult to scrutinize this planet on account of its own extreme brilliancy. So great is this that it is not unfrequently visible in full daylight, and is capable of casting a sensible shadow at night. This occurs every eight years, when the planet is at or near its greatest north latitude, and about five weeks from inferior conjunction. Its apparent diameter is then about 40 seconds, and the breadth of the illuminated part nearly 10 seconds, or rather less than one-fourth of the entire disc. This fraction transmits more light than the phases of greater extent, as the latter correspond to greater distances from the earth. The brilliancy of this planet is such that the daytime is to be preferred for its investigation. On its disc various spots of a dusky hue have from time to time been observed, and by close attention to these Schröter has deduced a period of axial rotation of 23 hours 21 minutes 7·98 seconds, which subsequent observations at Rome only slightly modified to 23 hours 21 minutes 23·93 seconds. Sir W. Herschel and others have generally admitted the existence of an atmosphere of considerable density. During the transits of 1761, 1769, 1874, and 1882, the planet was observed by several persons to be surrounded by a faint ring of light, which the existence of an atmosphere would account for. Schröter has calculated the horizontal refraction at the surface of the planet to amount to 30′ 34″, or about the same as that of the earth's atmosphere. The existence of snow at the poles of Venus has been suspected, and there is no *primâ facie* reason against it. The presence of mountains on its surface is likewise strongly suspected from inequalities in the lower region of the crescent, which could only be produced by mountains higher than those in the moon. A phenomenon analogous to the *lumière cendrée* or "ashy light" in the moon is noticed in observations of Venus when near inferior conjunction; this is no doubt caused by reflection, though at present it may be difficult to determine the precise nature of it or its cause.

The discovery of the phases of Venus is due to Galileo, who announced the fact to Kepler. For marine computations, owing to its rapid motion, Venus is a useful object for taking lunar distances, when continuous bad weather may have prevented solar observations. In computing the places of Venus, the tables of Le Verrier are employed, as they correct an error discovered by Sir G. B. Airy in 1846, affecting the heliocentric places of the Earth and the planet to a very sensible amount. This inequality goes through all its changes in about 239 years, and at a maximum displaces Venus by 3 seconds, and the earth by 2 seconds, as viewed from the sun.

THE EARTH. ⊕

The Earth is a planet in all essential respects similar to its nearest neighbours, Venus and Mars. It performs its revolution in an orbit round the sun in 365 days 6 hours 9 minutes 9·6 seconds, at a mean distance of 91,430,000 miles. The eccentricity of the earth's orbit amounting to 0·016, this distance may extend to 92,965,000 miles, or contract to 89,895,000 miles—differences which involve variations in the sun's light and heat reaching the earth, and which may be represented by the numbers 966 and 1033, the mean amount being 1000.

The form of the earth is that of a spheroid, like many and probably all of the planets. The latest authentic measurements are:—

Measurements.	Airy.	Bessel.
Polar diameter,	7899·170	7899·114
Equatorial diameter,	7925·648	7925·604
Absolute difference,	26·478	26·490
Excess of the Equatorial expressed as a fraction of the entire length,	$\frac{1}{299·330}$	$\frac{1}{299·192}$

The close coincidence between these results is a guarantee of the correctness of both, the difference between the two values of the equatorial diameter being only 77 yards.

The great circle of the heavens *apparently* described by the sun every year, owing to the revolution of the earth round that body, is called the *ecliptic*, and its plane is usually taken by astronomers as a fixed plane of reference. The plane of the earth's equator, extended towards the stars, marks out the *equator of the heavens* [see Plate I.], the plane of which

is inclined to the ecliptic at an angle of 23° 27′ 19·23″; this angle is known as the *obliquity of the ecliptic*. It is this inclination which gives rise to the *seasons* during the annual revolution round the sun, as will be readily understood by an inspection of Plate V., in which it must be remembered the size of the earth relatively to that of its orbit and of the sun has been greatly exaggerated in order to make the causes of the varying seasons plain. The two points where the celestial equator intersects the ecliptic are termed the *equinoxes*, and when the sun is at these points day and night are theoretically equal throughout the world; the points midway between these being the *solstices*, because the sun when it has reached these neutral points has attained its greatest declination north or south, as the case may be. It is from the vernal or spring equinox that *right ascensions* are measured along the celestial equator, and longitudes along the ecliptic.* The obliquity of the ecliptic is slowly decreasing at the rate of 48 seconds in 100 years. It will not always be on the decrease, as before it can have altered 1½ degree, the cause which produces this diminution must act in a contrary direction, and thus tend again to increase the obliquity. The change of obliquity can never therefore become sufficiently great to produce any sensible alteration of climate on the earth's surface. The eccentricity of the earth's orbit amounts, in accurate figures, to 0·0167917, and its small diminution does not exceed 0·000041 in a period of 100 years. Were this change to go on continuously the earth's orbit must eventually become circular, but by the theory of attraction it can be proved that this progressive diminution only proceeds for a certain time. Le Verrier has shown that this diminution can only continue for 24,000 years, when the eccentricity will be at its minimum of ·0033, and it will then begin to increase again. Unless some external cause of perturbation arise, these variations must continue throughout all ages, within certain restricted limits. They are due to the attractive influence of the planets. The value of the eccentricity given is for 1800·0 A.D.

The line of *apsides*, the line joining the points of perihelion and aphelion, is subject to an annual direct change of 11·77″, independent of the effects of precession, to be noticed hereafter; so that, allowing for the latter cause of disturbance, the annual movement of the apsides is rather more than 1′. One important consequence of this motion of the major axis of the earth's orbit is the variation in the lengths of the seasons at different periods of time. In the year 1267 A.D. the perigee coincided with the winter solstice; the spring quarter was therefore equal to the summer quarter, and the autumn quarter to the winter one, the former being the longest. In the year 6493 A.D. the perigee will have completed half a revolution, and will then coincide with the vernal equinox; summer will then be equal to autumn, and winter to spring, the former seasons being the longest. In the year 16945 A.D. the cycle will be completed by the coincidence of the solar perigee with the autumnal equinox. In consequence of the seasons being now of unequal length, the spring and summer quarters jointly extend to 186 days, while the autumn and winter quarters only comprise 178 days. The sun is therefore a longer time in the northern hemisphere than in the southern, hence the northern is the warmer of the two hemispheres. An incidental proof of this fact is that in the northern hemisphere navigators have reached 81° of latitude, whereas 71° is the highest attained in the southern hemisphere. Mädler gives the following as the greatest possible length of the day in different latitudes:—

0°	0′	12 hours.	65°	48′	22 hours.
16	44	13 "	66	21	23 "
30	48	14 "	66	32	24 "
41	24	15 "	67	23	1 month.
49	2	16 "	69	51	2 "
54	31	17 "	73	40	3 "
58	27	18 "	78	11	4 "
61	19	19 "	84	5	5 "
63	23	20 "	90	0	6 "
64	50	21 "			

The 8646 hours which make up a year are distributed as follows:—

At the Equator.	At the Poles.
4348 hours day.	4389 hours day.
852 " twilight.	2370 " twilight.
3446 " night.	1887 " night.

The following are the most recently calculated values of the mass of the earth compared with that of the sun:—Encke $\frac{1}{359551}$, Littrow $\frac{1}{355000}$, Mädler $\frac{1}{355499}$, and Le Verrier $\frac{1}{354030}$. In the present state of uncertainty as to the sun's parallax it is not possible to assign with confidence a more definite value.

PENMANSHIP.—CHAPTER III.

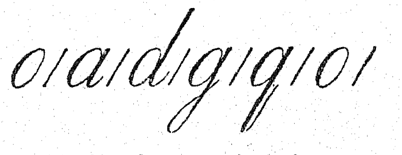
LARGE AND SMALL LETTERS—EXERCISES IN FACILITY AND GRACE—OVAL FORMS—HOGARTH'S "LINE OF BEAUTY"—COMPOSITION OF CAPITALS.

In books and in writing, in type or in script, letters have each two distinct forms, one used in the main body of the work, and the other employed to attract attention, denote distinction, and indicate eminence. The former are called small letters, or technically *minuscules;* the latter, capitals, or *majuscules*. Those chief letters, as their name implies, do not occur so frequently in writing or printing as the smaller ones; but, being designed to draw the attention of the reader to them, it is customary to endeavour to impart some special elegance to their form, and even to bestow some embellishment on their execution. While we are far from thinking that beauty of design and skill in manipulation are out of place in the practice of penmanship, we may quite properly caution young beginners and fanciful enthusiasts against indulgence in needless ornamentation in ordinary writing, especially if it have the effect, in any way, of so interfering with simplicity of penmanship as to prevent it from being easily read. Neatness is commendable, elegance is admirable; but over-ornament—what is usually called flourishing—is objectionable, unless where the chief end of the performance is, not the communication of information to the mind, but of gratification to the eye. In such a case, however, drawing supplants penmanship, which, as a general rule, ought to be kept free from any curious ornateness and all bewildering—even if bewitching—flourishing. Legibility is the chief charm in caligraphy. It is like intelligibility in composition, a priceless acquisition.

The figure which lends itself most readily to the imagination as the regulative form in good writing is the oval, represented by the letter *O* both in small-hand and in capitals. It might, on this account, be called *the graphic base*, the permanent and permeating element in penmanship. This oval is an oblong curvilinear figure, closely resembling the longitudinal section of an ordinary egg, not exactly a mathematical *ellipse*, which is correspondingly broad at both ends, but a veritable *oval*, being, though only slightly, somewhat broader at the base than at the vertex. It is easily seen in the minuscular letters that the oval *o*, though not the unit of measurement, is the graphic base in penmanship. In any classified arrangement of the letters we cannot fail to notice how frequently its form occurs. It is present (1) as a whole, in *a*, *d*, *g*, *q*; (2) as a part, in *c*, *e*, *v*, *w*, *b*, *s*, *x*; and (3) as regulative of the curves, in *i*, *t*, *n*, *m*, *u*, *r*, *l*, *h*, *y*, *p*, and *k*, leaving only as (partial) exceptions *j*, *f*, and *z*. The

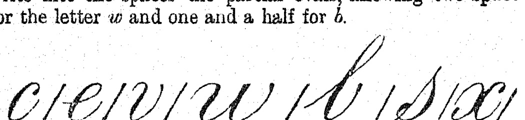
* The *right ascension* of a celestial body is its angular distance from the vernal equinox, measured on the equator of the heavens. This measurement is usually expressed by astronomers not in degrees, but in *hours*, *minutes*, and *seconds;* the *hour* in this case being one-twenty-fourth part of a complete revolution of the earth, and therefore equal to *fifteen degrees*. It will thus be seen that right ascension is the equivalent of what is called *longitude* on the earth's surface. Terrestrial *latitude* is represented by celestial *north* and *south declination*, which is the angular distance of a body north or south of the celestial equator, measured in degrees, minutes, and seconds. The subject will be best understood after a careful examination of Plate I., in which the equator, the ecliptic, and the equinoctial colure or meridian passing through the equinoctial points are all indicated in red.

utility of having such a regulative ideal, or type-form, before one's mind will speedily be recognized by any one who will diligently and intelligently practise the following exercises, which we can commend as exceedingly beneficial in educating the eye and training the hand in plain practical penmanship:—

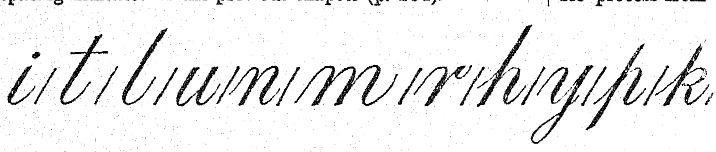


1. Draw with the ruler, on a sheet of paper, two horizontal parallel straight lines having a well-defined distance between them; in the interspace thus marked off, draw a series of sloping parallel straight lines —such as by schoolboys are commonly called strokes— equidistant one from another, and, having done so, write within each space, in the order given above, the complete oval letters.

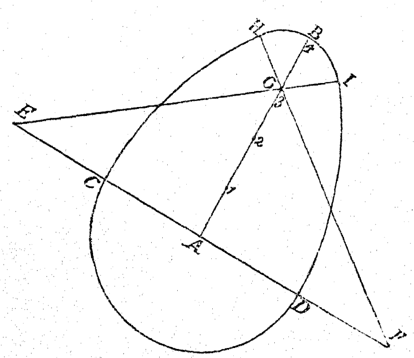
2. Having prepared the groundwork in the same way, write into the spaces the partial ovals, allowing two spaces for the letter *w* and one and a half for *b*.



3. In the same way write the oval curves, allowing the spacing indicated in the previous chapter (p. 164).

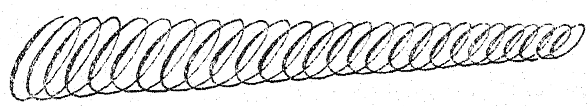


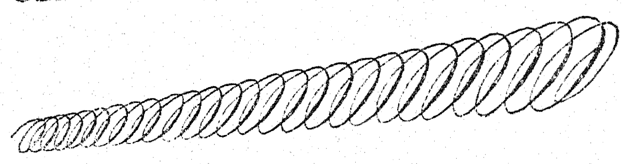
As it is advisable to have this type-form or graphic base distinctly before the mind, we supply directions for the drawing of an oval in an exceedingly simple manner, with an illustrative figure. Draw, first, a main slant straight line, A B, two heights' length of the body of the (intended) writing; at right angles to that sloping line, and passing through the point A, draw a straight line, E F, equal in length on each side to A B. Divide the line A B into the four equal parts 1, 2, 3, 4. Through point 3 draw straight lines from E and F,



meeting in G, and produced as at H and I. With F C as a radius describe the arc C H, and with E D as radius describe the arc D I. From the point A, with radius A D, describe the semicircle D C; and with point 3 (which is G), and G B as radius, complete the figure by describing the segment H B I; the resulting figure will be the oval required. It is advantageous, having the figure thus formed, to practise with a pencil-point the passing of the hand round the outline of the figure to induce flexibility of movement and facility of manipulation. This absolute geometric correctness of type-form is not indispensable if the learner can obtain any carefully executed oval form on which he may practise, or has a good example of a well-shaped capital *O*, which he can employ in a similar way for the same purpose. In whichever way this practical manipulatory power is attained, a most excellent mode of cultivating dexterity of curvilinear execution will be found in the following exercises:—

1. Rule a space for three heights, then draw a diagonal line from the left of the top line of ruling to the right of the third line, indicating the usual height of the main body of

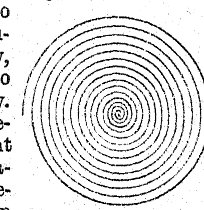




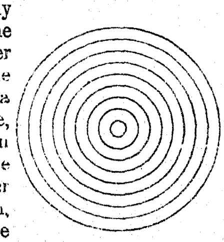
the letters, and under the diagonal line write a series of the letter *O* successively intertwined and constantly decreasing in size from left to right.

2. Invert the process, as shown above.

Another excellent exercise is to form a spiral—*i. e.* a curve which winds round its centre and in its progress continually increases its distance from that centre. With a pencil-point practise the following of the windings—(1) from outer circle to centre; (2) from centre to outer rim; and (3) repeating the double process from centre to periphery, and periphery to centre alternately. After having devoted a fair amount of pains and patience to the foregoing exercise in



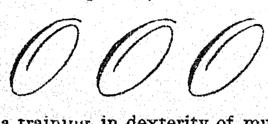
cursive dexterity and muscular manipulation, we shall be able to make a new preparatory step towards acquiring skill and readiness in the accomplishment of those rounding curves on which so much of the grace and readableness of writing depends. This may be done simply by forming a series of concentric circles—using, if necessary, a pair of compasses to make them perfect—which gradually decrease in circumference until the inner one is as small as the letter *o* in ordinary writing. Having done this, as exemplified in the figure, on a piece of paper, and in ink, if possible, take a sharp-pointed pencil, or an iron style resembling one of the points of the compasses, in order that the point may be distinctly seen, and leaning the arm freely upon the desk, or other sloped surface on



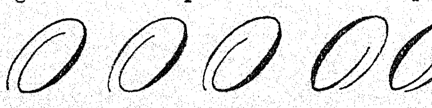
which the paper may be laid, cause the hand to carry the pencil freely round each of the circles, pressing as lightly as possible upon the paper until the eye and the hand together get thoroughly familiar with the revolutions required, and are drilled into ease, precision, and speed. This exercise should be continued (1) with the rotation from right to left; (2) with the rotation reversed from left to right; and (3) with alternate rotations. In the earlier drill the exercise should be begun at the exterior circle, proceeding gradually inward till the innermost is reached; then the process should be reversed, and the progress should be made from the inner to the outer. Nor ought the exercise to be given up till, on taking any one of the circles at random, the hand is found capable of gyrating as required with unmistaking accuracy and unhesitating facility. To put the success of the drill undergone beyond doubt, it is advisable to take a fresh sheet of paper, and to form on it with the compasses one perfect circle—preferably a medium-sized one; then (1) round this circle form with pencil or pen as many circles of increasing circumference as can be made with the free-wrist motion of the hand in any single position; (2) within it draw as many as it can easily

and distinctly contain—taking care that each is formed with one single continuous rotatory movement of the hand and fingers, and reproducing thus the previous figure round the one circular guiding line.

We can now revert to the oval, which is the regulating unit of measurement in capital letters. It rises above the base-line to three times the height of the unit of measurement *i*, in the small-hand writing adopted. Its width ought to be rather less than twice that of the unit of measurement, that is, scarcely two-thirds of its own height. Its two sides ought to curve equally. In writing it, we begin three heights above the base-line, come down gradually half-way with a full curve towards the left; we then make a full round oval turn towards the right, touching the base-line and sweeping the same oval turn into an upwardly curving line about a height and a half. We take in the curve towards the top about one-fourth part of a height, and making an upper oval turn bring down a light left curve-line, carrying it down parallel to the first-formed curvilinear portion of the letter to about the height assigned to the small letters. Besides the more strictly scientific manner of forming the oval given in the figure, it is often requisite to have a more readily available practical guide towards its form and measurements. To construct a capital *O* with proper adjustment and proportion of its separate parts, such as may form a pattern or a type, we proceed thus:—(1) Rule the paper to be written on so as to indicate the total height and the height of the main body of the small-hand letters; (2) draw, at an angle of 52 degrees, a main slant line reaching from top to base, and sloping from right to left; (3) bisect this with a straight line running an equal length on either side, and being in all scarcely two-thirds of the length of the main slant line. The points of these lines will form the boundaries of the oval in height and width; and the oval figure formed around these lines, according to the directions given above, will result in a regularly formed symmetrical capital *O*. In the process of its formation the student should notice that it naturally presents itself as made up of five parts. Of these the first is the left-hand upper quarter, which commences lightly at the top of the main slant line, and proceeds with a gradually thickening curve to the left extremity of the horizontal line. Here the great difficulty is so to strike out towards the left as to make the curvature go with a sufficiently rounded movement. In the second quarter the difficulty is just the opposite—to keep the shading gradually decreasing, and to carry the bend of the curve with a fine rounded turn onwards to the base of the main slant line. The third is precisely the reverse of the first, and ought to be exactly similar in curvature, but without shading. The fourth part requires careful sweep of curve so that it may not only be full and round, but so swirl towards the left as to be about a twelfth part of the whole height of the letter lower than the commencing point. The fifth part simply carries a thin parallel line down alongside of that in the first quarter, so as to extend a little below the extremity of the horizontal line on the left. The acquisition of skill in the forming of a capital *O* with freedom and elegance is of great consequence, not only as a training in dexterity of muscular movement and facility in fingering, but also as giving mastery over a type-form, which reappears with slight modifications in several other letters, as *E*, *G*, *C*, *D*.



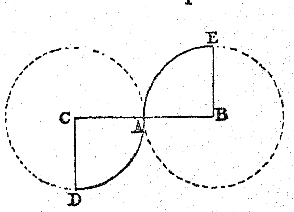
The next power to be gained is that of producing, at one stroke, an inverted oval. In doing this we reverse the process of the last exercise. Here we begin at the base-line, and, starting from the oblique line which would pass down

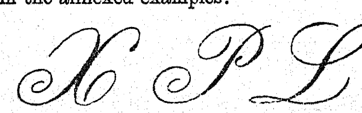


through the middle of our intended oval, make a long, full, gracefully sweeping curve round the left of the (imaginary) horizontal centre line right up three heights to the top, where a fully-rounded turn is to be made, such as shall bring the downward curve sweeping to the right, and then, bending into the left again finely shaded, swirling its oval back to the base again. The rounded sweep of the curve, and the proportions of the several parts—quarter to quarter—are here again the particular points to which attention is required. With some slight modifications and ornamental accessories, easily managed when we have mastered the mode of making the type-form dexterously, this inverted oval enters—either in whole or in part—into the composition of several capitals, *e.g.* *Q*, *U*, *Y*, which shall be shown in detail as we proceed.

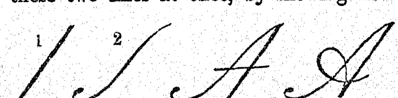
Having acquired a knowledge of the unit of measurement, we have next to acquire a main slant stem which, when known, will be found to constitute a chief element in the formation of many letters. A straight line is stiff and unornamental, an oval is graceful and flowing, but in itself incapable of many variations; and we want some line which shall lend itself freely to variety, yet impart a feeling of strength. Hogarth, in his "Analysis of Beauty" (1753), endeavoured to prove that the essential elements of strength and grace were to be found combined in a flowing serpentine line, which has acquired the name of "Hogarth's line of beauty." It is an easy, free, unconstrained double curve, gliding along in a wavy line of contrary flexure, so that it impresses us with a feeling of lithe progressiveness and power. To the eye it appears to be the result of a flowing free-hand movement, seemingly made without trouble or difficulty. This Hogarthian "line of beauty" certainly does enter into all the more elegant of our English capital letters. It starts with a gentle gradient of curvature, and having, as it were, wound itself in one direction to a certain extent, it seems to seek to equalize and balance that active curve by a complementary reactive one, and so presents one continuous line composed of two constituent arcs forming a singularly agreeable symmetrical whole.

Geometry shows us (Euclid III., 13) that circles external to each other can only touch one another at one point in each circumference. If we construct, as in the accompanying figure, two equal circles, having their equal radii A B, A C, one half of the height any capital letter is intended to be made, we shall have two tangent circumferences, the arcs of which, A E, A D, shall be similar but reversed. These two tangent arcs, when regarded as a continuous whole, will be seen to form a mixed sort of curvilinear line, presenting on the one side a convexity and a concavity, and on the other a concavity and a convexity. These two arcs, in their continuity and oneness, constitute the Hogarthian "line of beauty," or, as it ought rather to have been called, of grace; and supply the grace-line stem of the larger proportion of English capitals, as may be seen in the annexed examples:



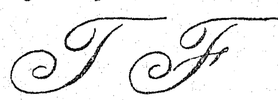


The best way to form an idea of the simple grace of line is to make an oblique straight line, with an angle of incidence of 52 degrees, and contrast it in its stiff self-sameness with the concurrent continuity of curve which the grace-line stem presents. The difference is perceptible to the least observant eye. We may illustrate this fact, and show the composite effect of these two lines at once, by showing how the two



elements combined form the letter *A*. Here the curved grace-line 2 and the straight line 1, suggestive of solidity and strength, unitedly form the letter *A*, the grace-line being formed rising from the left point towards the top, and being then joined to the sloping line—to which we add either a horizontal cross-line or an accessory backward curve. The

same grace-line gliding into a concave copartner one, but drawn downward from the top on the right and carried in a single sweep to the base on the left, appears in several other capitals, but in some cases it is subject to slight modifications. For example, *T* is formed of two grace-lines, one sloping and another balanced horizontally on the top of that. *F* is similarly made with a small additional grace-line crossing the stem.



In forming this grace-line stem, hold the pen with a gentle pressure between the thumb and the two forefingers. Move the hand freely and lightly, with a uniform unhalting sweep from top-height to base, so that wrist and fingers, co-operating together, may form a fine pair of equally curved segments nicely graduated into one another at their tangent. Care should be taken not to allow the hand to jerk round too suddenly at the turning, as that not only destroys the general grace of the line, but also flattens any curve or oval which may require to be attached to it for ornamental purposes, or, as it is sometimes called, flourishing.

LOGIC.—CHAPTER III.

JUDGMENT—PROPOSITIONS—CONVERSION.

NAMES, as we have seen, express conceptions of things thinkable. They are the mind's notes of reference regarding the impressions received and perceived. The common sum of ideas which persistently group themselves together into oneness, and make up, as it were, the substance of an idea, is embodied in a name. It then acquires logical validity as a sign of some distinct conception with which mind can deal. In it, simple apprehension has reached a term, and the whole worth and meaning which it bears may be made a subject of thought. Its meaning possesses a value partly—one might almost say principally—as a final symbol of a gradually completed course of elaborated perception; but it has also a meaning of value, partly and perhaps necessarily because it may be used as an agent in the attainment of a knowledge of something else than itself. A name may be said to encircle and mark off certain groups of ideas as constituting at once the extent and the content of a conception. Hence things can be classified through their names, and may be reasoned about by their help. Any comparison of ideas one with another, as to whether they are (1) similar to, (2) different from, (3) parts of, or (4) the same as one another, which the elaborative faculty may institute, results in a *judgment.*

In the formation of judgments the mind makes a new departure. It is no longer engaged with single conceptions and the simple elements which are found combined in them. These are supposed to have been gained by simple apprehension, and to be clear, adequate, without ambiguity or interchangeability. Any two conceptions being given to the conscious mind simultaneously, naturally excite it to discover whether they agree or conflict with one another, whether they will blend into one, coincide with each other, co-exclude or partially include and exclude one another; and having determined on this, the mind has formed a judgment.

The concepts which we compare together may be, (1) two ideas presented by the names which symbolize them; (2) two outward (or inward) things, *i.e.* experiences made objects of thought and represented to the mind by names; or (3) an idea and an individual thing or class of things. Our object in comparing them is to learn what relation of compatibility or incompatibility they hold one to the other. In this logical act of comparison or exercise of the judgment there are obviously three things really implied—visible apart to the critical faculty as elements, but indivisible in their mutual correlation in an act of thought. These are (1) the concept—set forth in a name—under the direct view of the mind for examination and determination; (2) the concept—also nameable—by whose agency or co-operation the comparison is to be made; and (3) the relation perceived—and to be expressed—between these two, and when the judgment is completed, affirmed, or denied regarding them. If we have, for instance, the two concepts *copper* and *malleable*, and consider whether these two can or cannot be thought together, the former is the determined subject of thought, the latter the one we are engaged in determining on, and we couple them together in the proposition, *Copper is malleable.*

A proposition is the articulate placing before our own minds or the minds of others, in words, the result of an act of judgment. The judgment is the formal logical act performed by the mind; the proposition is the material expression of the result of that act, or the act embodied in words. Of this proposition, copper is the *subject*, and malleable the *predicate.* The subject and the predicate are called the *terms* or *extremes* of the proposition; and that word by which those two terms or extremes are knit into a new unity of material relationship, is called the *copula.* The copula, however, need not be, as in this case it is, a separate word, but may be inherent and coalesce with the predicate, as in attributive verbs it generally does. We can say, for example, "Man thinks," *i.e.* Man (subject) is (copula) a thinking being (predicate).

Ideas may be connected one with another by acts of will, as in the sentence, "I shall regard all words as of three classes, nouns, verbs, and modifiers of them;" in imagination, as in wishing, *e.g.* "Were all the wealth of Indies mine;" in commands, "Do (you) what I bid you;" in questions, as "Are you serious?" &c.; but logic only recognizes that peculiar kind of assertion which the understanding makes in reasoning when it declares that a connection (of some stated sort) exists between two ideas, *i.e.* terms. In judgment we settle in our minds that there is (or is not) a relation between the subject and the predicate, and this result of the operation of the reflective faculties is stated in a proposition. It may not be a relation of identity, even though we couple them most closely. When we say "Honesty is the best policy," we do not probably mean that the things are one and the same. Here we only assert one logical subject of another; but if we are engaged in investigating the advantages of honesty, we may assert that it is the best policy. If policy signifies the means of managing affairs, and honesty is recommended as the best of these means, we are in reality eliminating from *honesty* what might be called its very essence, that of straightforward conduct unswayed by any considerations of advantage to self. It may only be a statement that one idea is so much more extensive than another that the subject is containable within it, *e.g.* "Patriotism is indispensable to the welfare of a community." Of things indispensable to the welfare of a community, while patriotism is one, it is not the only one. Wisdom, wealth, industry, courage, &c., may also be imperatively required. Again, it may only be the expression of a sense of the (possible) co-existence of two ideas, *e.g.* "Philosophers are investigators; men are passionate; tyrants are hateful." Positive statements made by the understanding alone fulfil the logical idea of predication. It must express itself as "is" or "is not." It is in such language that reason expresses itself, and hence the necessity of looking well to the forms of expression we use, and of seeing that they express nothing more and nothing less than (or otherwise different from) the realities of thought.

We shall proceed to consider these parts of a proposition in the order they generally take, and therefore refer to—

I. *The Subject.*—The special matter which engages our mind, and into the characteristics or relations of which we are examining, is the subject—because brought under the power and into the view of the reflective faculties; as, *God* is omnipresent. The subject may be—

(1) *Simple*, when it presents itself in a determinate or indeterminate noun, or a pronoun standing for a noun clearly understood; as, *Wages* are the reward of labour; *They* are given for work done (or to be done.)

(2) *Compound*, when several different objects are brought by it to be thought of as one; as, *Coal*, *wood*, *peat*, and *coke* are combustible.

(3) *Complex*, when it requires for the expression of the term an adjective or a proposition with a noun following it, or some other set of significant words to be thought together in union; as, *Successful statesmen* are highly esteemed;

Captains of industry possess great influence; *All violent policy* defeats itself; *They who win* are able to rejoice.

(4) *Inverted*, when it is placed after its verb; as, Thus is finished the *long struggle for fortune*.

(5) *Elliptical*, when left unexpressed; as, *Some* sin grievously (understand *men*, *women*, or *persons*); The commandment runs, "*Walk* circumspectly" (understand *ye*).

(6) *Indefinite*, when it does not clearly fix the idea to which it refers in the mind; as, *It* rains; *Everyone* is faulty in some respect.

(7) *Redundant*, when rhetorically repeated to impart emphasis; as *He*, he is the betrayer of our cause.

II. *The Copula.*—The mind, in thinking, searches among experiences, and therefore among the things which contribute or furnish experience to it, to find out which of them are like and which are unlike. Among some it perceives a certain amount of sameness, extending from slight similarity to absolute identity, and among others a certain amount of diversity, extending from slight divergency to absolute dissimilarity. The former it *as*sociates, the latter it *dis*sociates; affirms the connection of these, and denies—*i.e.* negatives—the connection of those. The sense of their affinity or separateness exists in the judgment as a substantive decision of thought, and expresses itself by the verb *to be*—in one or other of its forms, most generally in *is* or *is not*. This verb is therefore called the *copula* or conjoiner.

Is, it ought to be observed, does not, as a copula, cumulate, but combine ideas. Used in regard to names, concepts, and things, this simple substantive verb takes three distinct senses: (1) applies to—as, A jonquil is a narcissus; (2) possesses, contains, or presents the characteristics of—as, Iron is a mineral; (3) coincides (in whole or in part) with, or may be classed—as, Man is an animal; Neptune is a planet. This last *is*—sometimes called "the *is* of identity"—is not always indicative of absolute sameness or selfsameness, but varies from general to perfect likeness, so that it includes (1) absolute identity—as, My statement is the truth; (2) identity in certain understood or implied particulars—as, Othello is a Moor; (3) identity of possession or quality—as, The violet is blue; (4) identity (as a species included under a genus)—as, The poet is an author. There are besides these, the "*is* of existence" —as, Man *is*, *i.e.* Man is an existing being; and the mathematical "*is* of equality" in magnitude or number. These observations are necessary to enable the student to observe how, over and above, as well as within, the common colloquial use of *is*, there are implied differences which require attention, and to show him that it is essential in right reasoning to make sure that the most simple words in appearance are not so employed as to allow a fallacy to lurk in them. It is necessary to see, that the *is* used in the several propositions we lay down or accept is properly understood by thinker and hearer in the selfsame determinate sense—whatever that may be.

It will be perceived, then, that the verb is a sort of pivot, on each side of which there rests either the weight or the power of thought to be balanced in relation to each other, and which may be made to revolve, as it were, around it—as, Eagles are birds with strong wings, or, Some birds with strong wings are eagles. This is called *conversion*, a process to which we shall direct attention a little further on.

III. *The Predicate.*—The idea which is stated in a proposition to hold any particular relation to the subject is called the predicate. The predicate, like the subject, may be—

(1) *Simple*, when it contains and expresses only a single idea—as, The earth is *spherical*.

(2) *Compound*, if it includes more than one idea which are to be thought of in union in the same act of mind—as, Triangles are *composed of three sides and three angles*.

(3) *Complex*, when one idea is to be regarded as modified by another—as, Economy is *the true source of all wealth;* Amusement is *necessary for both old and young;* Men are *apt to act without reflection*.

(4) *Inverted*, when it is placed before the verb, *i.e.* in the usual position of the subject—as, *Great* is Diana of the Ephesians; *Merciless* is the irony of fate; *Irresistible* are the tears of beauty.

(5) *Elliptical*, when it is understood, not expressed—as, The sky is blue, and the sea also—*is blue* being omitted as easily supplied from the previous clause.

(6) *Redundant*, when it is intended to give increased emphasis or force to the idea—as, The greatest wonders are *seen by our own eyes without surprise*—where "by our own eyes" are not necessary and yet increase the force of the idea of certainty. Of course, only such redundancy as logically heightens the idea to be expressed is permissible; and unless it adds to and affects the sense, is carefully to be avoided as pleonasm. Reduplication may even, although apparently redundant, impart force to a predicate—as, Oppression is an insult to the people—*the sovereign people*.

The notion of *affirmation* is the consciousness in the mind that the agreement (in so far as the act of comparison has carried it) of the conceptions expressed by the terms of the proposition subsists and is real (in the combination between subject and predicate implied in it). The notion of *negation* is the consciousness in the mind of the want of real subsisting agreement between the terms of a proposition (in the actual form stated or implied in it). The proposition, "Man is mortal" is *affirmative;* "Man is not mortal" is negative. The technical term *quality* is used to indicate the basis of propositions as affirmative and negative.

A controversy has arisen among logicians as to whether the negative particle *not* belongs to the copula or to the predicate. One view taken is, that a non-copulative copula, *i.e.* a disjoining union, is a contradiction in terms, while a predicate implying privation, exclusion, or incompatibility involves nothing extraordinary, and therefore the negative sign ought always to be regarded as attached to the predicate. The adherents of the older logic reply that every affirmation, so far as it extends, implies a negation to an extent equivalent to all that is excluded from the affirmation made; that hence the copula necessarily presents itself as performing the double function of affirmation of all that is said and denial of all that contradicts that assertion; that is, as containing in itself at once *is* to all included in the statement, and *is not* to all excluded from it—*i.e.* not introduced into it. "The nut *is* ripe" and "the nut *is not* ripe" exhausts the form of the relation between the subject and its predicate in a judgment. The judgment recognizes the subject and the predicate as reciprocally connected in a special relation of extension or of comprehension, or as not standing in or holding that relation; and if it expresses this judgment in a proposition, that must set forth one or other of these forms of the case. We must take care, however, that the precise significance of the proposition used is exactly represented by the form given to it, or we must see that the form of the proposition does not mislead us. It is true that when we affirm that "Some men are wise" we imply that "All men are not wise," or we should not have made use of the selective *some* in connection with the subject; but if we say "Some men are fools" we do not imply by it a corresponding negative, "All men are not fools." This arises from the fact that *fools* is a privative term, and is a part of *not-wise*. On this account the proposition quoted, though apparently affirmative, is in reality negative, and is equal to "Some men are not wise." We see that this is the case when we employ the sentence "He is no fool." By this we mean to say "He is really wise." Two negatives constitute an affirmative; *no* is the one, the other is included in the predicate *fool*, which is equal to *not-wise*. The great point which logic endeavours to secure is consistency of thought. As a means of securing this it insists on consistency of statement, and we can only know whether a statement is self-consistent when we thoroughly comprehend its terms and their relations. The words we use recall and keep in the mind's view the facts on which it has been deciding, or place them before another's understanding for acceptance. Logic requires that all that is implicitly involved in any proposition should be explicitly understood—that words and thoughts, in short, should be precise equivalents, for we can only rationally deal with what we distinctly apprehend and know. We must determine what is meant before we can effectively deal with its meaning; hence the necessity of forming clear conceptions of the entire signification of propositions in their parts and as a whole. Logic, however, does not bind a reasoner to the assertion of all the implications which

may by any possibility be drawn from the words in which a proposition is expressed. That alone which is distinctly and unambiguously expressed in a proposition is taken as its meaning, and while nothing more or anything different is not to be imported into it, nothing less than its whole intended signification is to be substituted for it. This canon of logical language demands, therefore, three things—(1) that ideas be distinctly apprehended; (2) that words precisely expressive of these ideas be employed; (3) that the relations between ideas be adequately indicated. By slight and almost impalpable differences in the use of language, the nicety and precision of thought are liable to be obscured, and therefore it becomes imperative on us to avoid this evil, as far as we can, by the carefulness with which we test the accuracy and effectiveness of this subsidiary instrument of thought. It is to secure the most definite possible knowledge of the statements made in propositions that logicians direct attention to the nature, characteristics, and implications of the three separate parts of a proposition, viz. (1) the subject, which determines its quantity; (2) the copula, which fixes its *quality;* and (3) the predicate, whose relation to the subject it is the main purpose of the judgment to settle and set forth. Besides this twofold division as to *quality*, propositions are also distinguished from each other by *quantity*. The *quantity* of propositions relates to the extent of their contents—the number or amount of the things or qualities which we include at one time in our judgment. Terms may be (1) both *individual*, in which case the relation of identity or diversity is the only one that can be expressed—as, Simon Peter, son of Jonas, was Cephas, the apostle of Jesus Christ; (2) one individual and the other collective, in which case inclusion within or exclusion from any collection of individuals or things possessed of certain characteristics may be predicated—as, Judas Iscariot was the traitor; or (3) both collective, and between two unities of such sort identity or diversity can be predicated in three ways—(*a*) between any (or every) individual of one collection and any (or every) other—as, every equiangular triangle is also an equilateral one; (*b*) between any (or every) individual referred to by one term, and any (or some) special part of the individuals designated as an aggregate by another—as, A triangle is a figure formed in space; and (*c*) between any one (or some, *i.e.* a part) of the ideas conveyed by one term, and any one (or some, *i.e.* a part) of those denoted by the other—as, Some quadrupeds are animals able to swim.

If a whole is a unity, which contains in it a plurality of parts (*i.e.* of component characteristics), the parts which go to constitute its unity are said to be contained *in* it, and so become the idea or measure of its internal intensity or *comprehension*. In this case (1) the parts of a part are parts of the whole; and (2) any aggregate of these parts is part of the whole—as, Man, as living, sensitive, and organized, is an animal. If a unity contains under it a plurality of characteristics or subordinate ideas, holding each to it the relations of particulars included in, and together forming, a general idea, they are said to be contained *under* it, and are the parts of its external sphere or *extension*, in which case also all that is contained under the more specific part is contained also in the totality of the higher extension—as, English, German, and French men are Europeans. Extension and comprehension are the inverse of each other. In extension ideas may be (1) exclusive, *i.e.* having no part of one coinciding with any part of the other; (2) inclusive, *i. e.* having their parts coincident, as (*a*) coextensive; (*b*) co-ordinate in making up a whole; (*c*) ordinate in the two different forms of superordinateness and subordinateness; or (*d*) partially inclusive, partially exclusive, *i. e.* having their spheres intersecting each other to a greater or less extent. On them depend classificatory judgments. In comprehension, totalities must either agree or differ. Agreement proceeds from identity downwards. This may be either complete or partial. Difference is twofold—(1) immediate and total, or *contradictory;* or (2) mediate and partial, or *contrary*. In the former only two conflicting ideas are conceivable, and these are reciprocally opposed one to another, so that the denial of the one implies the affirmation of the other. In the latter, more than two conflicting (or at least incompatible) ideas are possible, the affirmation of one of which removes from the mind at the time the possibility of the coexistence of the other. Immediate or contradictory opposition is the ground of affirmation and negation, and mediate or contrary opposition is the ground of subalternation, and these qualities of propositions bring them into opposition—(1) as contradictories; (2) as contraries. Hence it is that they are capable of conversion.

Conversion is the transposition of the terms of propositions, so that the subject becomes the predicate, and the predicate the subject. The original proposition is the *convertend*, the transposed proposition the *converse*. In conversion no term should be distributed in the converse that is not distributed in the convertend. When terms are employed in their wholes of extension or comprehension they are said to be *distributed;* when they are to be understood as taken in their parts they are said to be *undistributed*. Taking *quality* and *quantity* together we have four classes of propositions:—(1) *Universal affirmatives*, in which the subject is distributed and the predicate undistributed; (2) *universal negatives*, in which both are distributed; (3) *particular affirmatives*, in which both are undistributed; (4) *particular negatives*, in which the subject is undistributed and the predicate distributed. In conversion the quantity of propositions must always be preserved, that is, the converse must exactly equal the convertend. Hence the quantity of every term, though its expression may be elided in common speech, must always be present in the mind as one of the necessities of thought, otherwise thought would not be thoroughgoingly and self-sufficiently consistent. In a universal proposition one term must either be placed wholly *in* or wholly *out* of the other. Hence we see that in all universal propositions the subject is taken in its totality, while in affirmatives the predicate is taken in part, and in negatives in whole. In particular propositions, of course, the subject is taken only in part, but in affirmatives the predicate is taken in part, and in negatives in wholes.

The four vowels, A, E, I, O, are used to denote respectively—A, universal affirmative; E, universal negative; I, particular affirmative; O, particular negative. In particular propositions the greater the co-inclusion or the less the co-exclusion the more easy and direct the conversion, and the greater the co-exclusion or the less the co-inclusion the more difficult and less direct is the conversion. Hence follows the logical rule—A *distributes the subject*, E *both its terms*, I *neither*, and O *the predicate*. The four possibilities of *quantity* are (1) toto-total, complete co-inclusion or co-exclusion; (2) toto-partial, inclusion of a whole in, or exclusion of a whole from, a greater whole as part of it; (3) parti-total, the inclusion of a part into, or the exclusion of a part from, some whole; (4) parti-partial, the inclusion of a part of one whole into, or its exclusion from the part of, another whole. Examples:—

1. { All equiangular triangles are equilateral ones.
   No seaweed is any flower-bearing plant.
2. { All vices are some odious things.
   No vices are some meritorious things.
3. { Some animals are all dogs.
   Some dogs are not all animals.
4. { Some dogs are some of the swift animals.
   Some dogs are not some of the swift animals.

It accords with everybody's experience that the same idea can be, and is often, expressed in different words; "just as," to quote W. S. Jevons, "we can mould the same clay into different forms, though it always remains the same clay." So we can convert "All things may be useful" into "There are no things which may not be (some) useful things;" "The wise are happier than kings," into "Happier than kings are those men who are wise." In conversion, however, we must remember that a proposition is laid down as expressive of a certain equation of one idea with another idea, and we must always take care that we do not increase or lessen the precise relative quantity of the several terms. Logicians have laid down rules for our guidance in conversion. The matter of a proposition may be either (1) *necessary*, when all affirmatives are true, all negatives false; (2) *impossible*, when all negatives are true and all affirmatives false; (3) *contingent*, in which case all particulars must be true and all universals false.

In order that conversion may be at once legitimate and illative—*i.e.* that the converse may be exactly equivalent, as to truth or falsehood, with the convertend—no term must be distributed in the one which was not distributed in the other. Thus any proposition may be employed in a substitutive form if we distinctly secure the express equation of subject and predicate. Though the quantity of the subject is expressed, and that of the predicate is not expressed, yet the latter is necessarily implied in the meaning we put into or receive from a sentence, and this implication we are bound to make explicit whenever we require to make any matter clear. Universal negatives and particular affirmatives are necessarily convertible; but universal affirmatives and particular negatives are not so, and must be converted, if at all, by some such change as may bring out the true equivalence of the parts transposed.

I. Simple conversion is possible in E, which distributes both terms, and I, which distributes neither—as, No coin is combustible; No combustible thing is a coin. Some men are poets; Some poets are men.

II. Conversion *per accidens* is possible in A by change of quantity, so that while implying no change of relation between the terms used, we express no more agreement in the converse than we did in the converted proposition—as, All coins are made of metal; Some things made of metal are coins.

III. Conversion by negation changes the quality while preserving the quantity, and is possible in A and O—as, All wealth is transferable, limited in supply, and productive of pleasure or preventive of pain; Nothing which is not transferable, limited in supply, productive of pleasure, or preventive of pain, is wealth. Some arithmetical rules are not scientific; Some things not scientific are arithmetical rules.

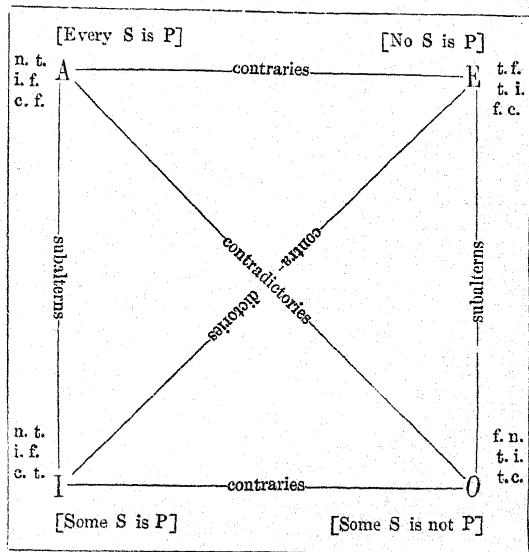
A and E are contradictories, I and O contraries: A and I or E and O subalterns.

The practical utility of the study of the quantity and quality of propositions is this—that it enables us to comprehend and test the full force of any statement, how much it really includes and signifies. A knowledge of conversion is valuable, because it provides us with the power of exhibiting any argument in that form of expression which best fits it for the particular purpose in view, whether that be (1) the placing of the matter before the mind in the full power of its insisting on or its resisting any statement, or (2) in bringing it to bear upon any argument which may be used against it, or against which it may be used. In fact, the object of conversion is to train the mind in the management of propositions, and to accustom it to turn a statement round and round in every possible way, so as to see if it will take any clearer form, or one better fitted to maintain the argument we may be endeavouring to substantiate by it. As an aid to the critical examination of statements made in arguing it is highly valuable as a detecter of the very common practice of substituting in a converse what is really a different judgment altogether, instead of what it should be, precisely the same judgment in another form. Conversion gives mobility to phraseology, and enables those who can use it well to re-adapt their statements to suit the new phases of argumentation, just as a general gains new advantages by transforming his battalions, according to the nature of the ground, the positions of the enemy, and his own purpose, now into circles, again into tr angles, at another time into squares, and even, if need be, by extending them in a "thin red line."

Exercise.—Take the following four propositions and the undergiven table, and work out from it all the possible forms which these propositions can take :—

A (Universal Affirmative)—All planets are inhabited.
E (Universal Negative)—No planets are inhabited.
I (Particular Affirmative)—Some planets are inhabited.
O (Particular Negative)—Some planets are not inhabited.

S stands for subject, P for predicate, *n* necessary, *i* impossible, *c* contingent, *t* true, and *f* false.



The study of the following tables will serve to recall at a glance the main matters requiring to be remembered in connection with the logical doctrine of propositions :—

I. Propositions are

- 1. Simple.
  - 1. Incomplex.
  - 2. Complex.
    - (1) Determinative.
    - (2) Explanatory.
- 2. Compound.
  - 1. Expressed.
    - (1) Copulative. (2) Disjunctive.
    - (3) Conditional. (4) Causal.
  - 2. Understood.
    - (1) Exceptive. (2) Comparative.
    - (3) Exclusive (in whole or in part)

II. Propositions are distinguishable in regard to

- 1. Quality.
  - 1. Affirmative. 2. Negative. 3. Indesignate.
- 2. Quantity.
  - 1. Universal. 2. Particular. 3. Indefinite.
- 3. Modality.
  - 1. Necessary. 2. Contingent. 3. Impossible.

CHEMISTRY.—CHAPTER IV.

SUMMARY OF MOLECULAR CONSTITUTION OF MATTER—CHEMICAL NOTATION—CHEMICAL SYMBOLS—NOTATION OF CHEMICAL COMBINATIONS.

In order to render the system of *chemical notation* clear, the molecular constitution of matter, upon which this notation is based, will be briefly summarized.

1. All substances are collections of molecules, and in these molecules their characteristics inhere; what is true of the substance is true of the molecule.
2. The molecule is an aggregate of atoms—sometimes of atoms of the same kind, as in elementary bodies, sometimes of atoms of different kinds, as in compound bodies.
3. The molecules are destructible, the atoms are indestructible.
4. Chemical change consists in the production of new molecules by the rearrangement of the atoms of former molecules.

In chemistry the initial letter of the Latin name of the elementary substance is employed to represent that mass of each element termed an atom. Thus O represents one atom of oxygen, N one atom of nitrogen, C one atom of carbon, Cl one atom of chlorine, Cr one atom of chromium, Fe one atom of iron (Lat. *ferrum*), and so on; it is only in a few cases that the Latin initial differs from the English. These symbols represent a definite weight, that is, *the weight of the atom* of the substance. Therefore, O stands for 16 units of weight, which is the weight of the oxygen atom. C stands for 12 units of weight, which is the weight of the carbon atom; and in every case the chemical symbol stands for the atomic weight, or proportional number, given in the table of elements, page 91. In order to represent several atoms, figures are placed below the symbol to represent the multiples; thus, O_3 means three atoms, or 48 units of weight of oxygen; C_6 six atoms, or 72 units of weight of carbon; and so on.

The *molecule* is represented by combining together the symbols of the atoms of which it consists, indicating the numbers of each kind of atom by the figures under the symbol. Thus, a molecule of water consists of three atoms, two of hydrogen and one of oxygen; therefore its symbol will be H_2O. And this symbol indicates not only that the molecule consists of three atoms, but also that it contains 2 units of weight of hydrogen and 16 units of weight of oxygen, and that this molecule of water weighs 18 units. If it is desired to represent several molecules of water, a numeral representing the number is placed before the whole symbol. Thus $2H_2O$ represents two molecules of water, $7H_2O$ seven molecules of water, and so on. As in all chemical relations what is true of the molecule is true of the substance, the symbol H_2O may be regarded as the symbol of water. Taking a further illustration: a molecule of alcohol is known to consist of two atoms of carbon, six atoms of hydrogen, and one atom of oxygen. The symbol of the molecule of alcohol is therefore C_2H_6O. The chemist consequently at once understands that a molecule of alcohol contains two atoms or 24 units of carbon, six atoms or 6 units of hydrogen, and one atom or 16 units of oxygen, and that the total atomic weight of the molecule of alcohol is 46 units. This forms the whole system of chemical notation and chemical symbols. The single letters stand for atoms, and the terms formed by grouping the letters represent molecules. This system of notation is also used to express chemical changes. Thus, taking sodic carbonate, known familiarly as soda, its molecules are each formed of six atoms—two of a metal, sodium, one of carbon, and three of oxygen. Its symbol is therefore Na_2CO_3. Again, taking muriatic acid, which is a solution in water of hydrochloric acid, a gas $18\frac{1}{4}$ times as heavy as hydrogen, the molecular weight of which will therefore be $36\frac{1}{2}$, and the molecules of which consist of one atom of chlorine and one of hydrogen. Its symbol is therefore HCl, and the condition of aqueous solution is expressed by the addition of the letters Aq, the initial of *aqua*, the Latin name for water. The symbol for muriatic acid therefore stands HCl+Aq. When this acid is poured on the soda, violent effervescence takes place, and large quantities of gas are evolved, which soon fill the containing jar. The old substances, the soda and the hydrochloric acid, and the water have disappeared; a new product has been formed by a process termed in chemistry a *reaction*, consisting of a large volume of colourless gas of considerable weight, carbonic dioxide, familiar by the old name of carbonic acid gas—a compound of one carbon and two oxygen atoms; symbol therefore CO_2. The other products are water and common salt, which dissolves as it forms in the water present, but which may easily be isolated by evaporating the brine.

Common salt is composed of a metal, sodium, and chlorine gas. Its molecules consist each of an atom of sodium and an atom of chlorine. Its symbol is therefore NaCl. Writing the factors of this reaction opposite to the products, they can be compared.

Na_2CO_3	HCl	NaCl	H_2O	CO_2
Sodic Carbonate.	Hydrochloric Acid.	Sodic Chloride (common salt).	Water.	Carbonic Dioxide.

Here, then, are all the factors and all the products, and as atoms are indestructible, no material is lost; and there must therefore be just as many atoms of each element in the products as there are in the factors, and *vice versa*. As there are two atoms of sodium in the molecule of sodic carbonate, there must be two atoms of the same element in the products; NaCl is therefore 2NaCl. Again, the molecule of water in the products has two atoms of hydrogen; therefore 2HCl must be written among the factors. The reaction therefore becomes, $Na_2CO_3 + 2HCl = 2NaCl + H_2O + CO_2$. As the quantity of material represented among the products exactly equals that represented among the factors, the atomic weights of both sides should be equal, and

$$(23\times 2)+12+(16\times 3)+2(1+35{\cdot}5)=$$
$$2(23+35{\cdot}5)+2+16+12+16\times 2;$$
$$\text{or, } 179=179.$$

By examining the chemical change as thus written out, it will be seen that in the process each molecule of sodic carbonate is acted upon by two molecules of hydrochloric acid. The two atoms of sodium (Na_2) from the molecule of sodic carbonate (Na_2CO_3) unite each with an atom of chlorine (Cl) from the two molecules of hydrochloric acid (2HCl), and there are thus formed two molecules of common salt (2NaCl). Meanwhile, the original molecules having been broken up, the other atoms group themselves together to form a molecule of water (H_2O) and a molecule of carbonic dioxide (CO_2). The chemical change, therefore, consists in the breaking up of the old molecules and the rearrangement of the atoms to form others, and the system of symbols enables the various steps of the process to be followed. The equation above simply represents the reaction between one molecule of sodic carbonate and two of hydrochloric acid. As in the experiment there were billions upon trillions of molecules, the action here represented is simply so many billion trillion times repeated. In the reaction just examined, in order that the molecules of the one body should act on those of the other, it is necessary that they should have a certain freedom of motion, for if the molecules had been rigidly fixed in the material of the two substances it would have been impossible for them to arrange themselves in the manner pointed out, the two of one substance associating with one of the other in the resulting chemical process. There are in general two ways by which the required freedom of action can be obtained. One is to convert the substance into a vapour, when the molecules become completely isolated, and move with great velocity through space, their motion being only limited by the sides of the containing vessel. This method is, however, only applicable to volatile bodies. The other method is to dissolve the solid in some solvent, when the molecules become isolated and move freely through the mass of the liquid. Water, being a convenient solvent, is the vehicle generally employed to bring substances together, and for this reason it enters into a very large number of chemical changes. In the reaction under notice, both the sodic carbonate and the hydrochloric acid were dissolved in water. There are a great many substances which will act on sodic carbonate like hydrochloric acid, such as the acid salts, of which one is cream of tartar. If some sodic carbonate and cream of tartar, both in fine

powder, are carefully mixed together, no action whatever takes place, and in a dry place the mixture might be kept indefinitely without change. If the mixture is placed in a glass vessel and water poured over it a brisk effervescence at once takes place, and carbonic dioxide is evolved. The water was therefore required to bring the molecules together. As the water plays such an important part in the reaction its presence is indicated by the symbol Aq.

$$(Na_2CO_3+2HCl+Aq)=(2NaCl+H_2O+Aq)+\overline{CO_2}$$

Solution of sodic carbonate and hydrochloric acid. — Solution of common salt and carbonic dioxide.

This indicates that both the factors are in solution, and also that one of the products is a solution of common salt. The second product, carbonic dioxide, being a gas, is indicated as such by a line drawn over the symbol. The second reaction is equally simple, but the symbol of cream of tartar is $HKC_4H_4O_6$, as its molecule is much more complex than HCl. Thus it contains four atoms of carbon, five atoms of hydrogen, six atoms of oxygen, and one atom of potassium. One of the atoms of hydrogen is written apart from the rest, as it has a very different relation to the molecule. The reaction would be written:—

$$(Na_2CO_3+2HKC_4H_4O_6+Aq)=$$
$$(2NaKC_4H_4O_6+H_2O+Aq)+\overline{CO_2}$$

Solution of Rochelle salts.

This reaction is familiar as a mode of raising dough in the process of making bread. The first member of the equation shows that the two substances are used in solution. There is formed, as the product of the reaction, besides the carbonic dioxide gas which swells up the dough, the solution of a salt, which is the well-known medicine, Rochelle salts. Therefore, when soda and cream of tartar are employed in making bread, this medicinal salt remains in the loaf. The amount may be too small to be injurious, but chemicals are certainly better kept out of the domestic economy of the kitchen.

Upon closer examination of the formula,

$$(Na_2CO_3+2HCl+Aq)=(2NaCl+H_2O+Aq)+\overline{CO_2},$$

as each symbol stands for the known weight of the atoms, the weights of the molecules which the several terms represent may be found by adding up the weights of the several atoms of which they consist. Thus, Na_2CO_3, the weight of the molecule, is $(2\times 23)+12+(3\times 16)=106$ unit atoms, and if the several terms are all treated in the same way the formula will be

$$(\overset{106}{Na_2CO_3}+\overset{73}{2HCl}+Aq)=(\overset{117}{2NaCl}+\overset{18}{H_2O}+Aq)+\overset{44}{CO_2}.$$

The water, Aq, being merely the medium of the reaction, is not changed, and may be omitted. It will thus be seen that the weight of the factors, 179, is exactly equal to the weight of the products, 179, in the reaction; and that in addition to the information which the equation gives about the manner in which the chemical change takes place, the symbols also state that 106 parts by weight of sodic carbonate are acted upon by 73 parts by weight of hydrochloric acid, and produce 117 parts of common salt, 18 parts of water, and 44 parts of carbonic dioxide. If, therefore, there had been the least excess of either one or other substance over the proportions stated, that excess would have been wasted and left behind with the salt and water. Thus, if there was any weight of sodic carbonate, say 850 grammes, and it was desired to know what amount of hydrochloric acid was necessary to be employed, the equation gives $106:73::850:x=585\tfrac{40}{106}$. Again, if the amount of common salt produced from these amounts is required, then $106:117::850:x=938\tfrac{22}{106}$. Therefore in any process after the above reaction is written, and the weight of any factor or product is known, the weight of any other factor or product may be obtained. The rule is, therefore, *As the total molecular weight of the substance given is to the total molecular weight of the substance required, so is the given weight to the required weight.* The total weight is the weight of the number of molecules which the equation requires. This is perhaps the most important rule in chemistry.

In *chemical nomenclature*, originally based on the dualistic theory of Lavoisier in 1787, considerable changes and modifications have within the last few years been made the better to adapt the names to the more modern ideas, though chemical symbols supply to a great extent, in modern chemistry, the place of the philosophical names. The names of the elementary substances are necessarily arbitrary. Those known previous to 1787 retain their original name, as *iron, gold, phosphorus, sulphur*, and several others. The more recently discovered elements have generally been named in connection with some chemical property, or some circumstance in relation to their history; as *oxygen* (from the Greek), acid generator; *hydrogen*, water generator; *chlorine*, green; *iodine*, violet; *bromine*, fetid odour. All the names of newly-discovered metals have a common termination, *um;* as *potassium, sodium, platinum;* the names of several of the non-metallic elements end in *ine;* as *chlorine, bromine, iodine, fluorine.*

In *binary compounds*, or those which consist of only two elements, the simple compounds of the other elements with oxygen are all termed *oxides;* and to distinguish the different oxides the Latin name of the element in combination with the oxygen is generally employed; as—

Argentic oxide, ...	Ag_2O
Stannic oxide, ...	SnO_2

When the same element forms two compounds with oxygen, the termination *ic* is retained for the higher oxide, and *ous* for the lower; as—

Ferr*ous* oxide, ...	FeO.
Ferr*ic* oxide, ...	Fe_2O_3.
Sulphur*ous* oxide, ...	SO_2.
Sulphur*ic* oxide, ...	SO_3.

If there are more than two oxides the necessary distinctions are made by means of Greek numeral prefixes:—

Nitrous oxide, ...	N_2O.
Nitric oxide, ...	NO.
*Di*nitric *tri*oxide, ...	N_2O_3.
Nitric *di*oxide, ...	NO_2.
*Di*nitric *pent*oxide, ...	N_2O_5.
Carbonic oxide, ...	CO.
Carbonic *di*oxide, ...	CO_2.

The names of the *binary compounds* of the other elements are formed like those of oxygen, thus:—

Compounds of	Chlorine	are termed	Chlor*ides*.
"	Bromine	"	Brom*ides*.
"	Iodine	"	Iod*ides*.
"	Fluorine	"	Fluor*ides*.
"	Sulphur	"	Sulph*ides*.
"	Nitrogen	"	Nitr*ides*.
"	Phosphorus	"	Phosph*ides*.
"	Arsenic	"	Arsen*ides*.
"	Antimony	"	Antimon*ides*.
"	Carbon	"	Carb*ides*.

The specific names in the several classes of compounds also follow the analogy of the oxides, as—

Stannous chloride, ...	$SnCl_2$.
Stannic chloride, ...	$SnCl_4$.
Diferrous sulphide, ...	Fe_2S.
Ferrous sulphide, ...	FeS.
Ferric sulphide, ...	Fe_2S_3.
Ferric disulphide, ...	FeS_2.

The termination *ide* always indicates a compound containing only two elements.

Acids are the most prominent class of compounds of three or more elements; and the greater part of the inorganic or mineral acids are composed of two elements, hydrogen and oxygen, combined with some third element, which forms the characteristic constituent in each case, and from which the acid takes its name. As in the case of binary compounds, the

terminations *ic* and *ous* are employed to indicate a greater or less amount of oxygen in the compound, thus—

Nitr*ous* acid,	HNO_2.
Nitr*ic* acid,	HNO_3.
Sulphur*ous* acid,	H_2SO_3.
Sulphur*ic* acid,	H_2SO_4.
Phosphor*ous* acid,	H_3PO_3.
Phosphor*ic* acid,	H_3PO_4.

In every acid the hydrogen it contains may be replaced by different metallic elements, forming a class of compounds termed *salts*. The generic name of the salt of each acid is formed by changing the *ic* of the name of the acid into *ate*, or the *ous* into *ite*, as—

Sulphur*ous* acid	forms	Sulph*ites*.
Sulphur*ic* acid	"	Sulph*ates*.
Phosphor*ous* acid	"	Phosph*ites*.
Phosphor*ic* acid	"	Phosph*ates*.
Carbon*ic* acid	"	Carbon*ates*.
Silic*ic* acid	"	Silic*ates*.

The different salts of the same acid are distinguished as before:—

Nitric acid,	HNO_3.
Sodic nitrate,	$NaNO_3$.
Potassic nitrate,	KNO_3.
Argentic nitrate,	$AgNO_3$.
Sulphuric acid,	H_2SO_4.
Potassic sulphate,	K_2SO_4.
Calcic sulphate,	$CaSO_4$.
Mercur*ous* sulphate,	Hg_2SO_4.
Mercur*ic* sulphate,	$HgSO_4$.
Ferr*ous* sulphate,	$FeSO_4$.
Ferr*ic* sulphate,	$Fe_2(SO_4)_3$.

The terminations *ous* and *ic* of these salts indicate the same difference in the condition of the metallic element which determines the union of the metal with more or less oxygen.

The class of compounds called *hydrates* are derived from water by replacing one-half of its hydrogen, thus—

Potassic hydrate,	KOH.	From	HOH.
Calcic hydrate,	CaO_2H_2.	"	$2HOH$.
Bismuthic hydrate,	BiO_3H_3.	"	$3HOH$.
Silicic hydrate,	SiO_4H_4.	"	$4HOH$.
Ferr*ous* hydrate,	FeO_2H_2.		
Ferr*ic* hydrate,	FeO_6H_6.		

When the hydrogen of an acid is only partly replaced, or is replaced by more than one metallic element, the constitution of the resulting salt may be indicated, as—

Hydro-disodic phosphate,	HNa_2PO_4.
Potassio-aluminic sulphate,	$K_2Al_2(SO_4)_4$.

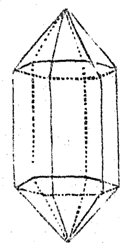
CHAPTER V.

CRYSTALLOGRAPHY.

Almost every substance, simple or compound, in passing from the liquid or gaseous into the solid state, assumes some definite geometrical figure, usually bounded by plane surfaces, and having angles of constant value, by which it can be distinguished; such a body is termed a *crystal*. Inorganic bodies which do not assume crystalline structures, such as glass, glue, &c., are said to be *amorphous*. Certain highly complicated structures found in the vegetable and animal world exhibit a structure which, although non-crystalline, partakes of systematic arrangement, and to which the name of *cellular structure* has been given.

In all parts of the mineral kingdom bodies in the form of polyhedrons are met with, many exceedingly irregular, but all bearing evidence of a law of formation, which it is the great business of crystallography to detect. Thus, all the precious stones are crystals, and can be well cut only parallel to their natural faces. The transparent substance rock crystal (pure quartz) is found in prisms of six sides terminated by six-sided pyramids, as shown in fig. 1. Common quartz differs from this only in exhibiting less regularity in its external forms. Iceland spar, which is pure carbonate of lime (the same in chemical composition as chalk, common limestone, and marble), is found in four-sided prisms, but the opposite sides only are equal to each other. Diamonds occur in regular eight-sided forms (octahedrons); and the fluor-spar of Alston Moor and Derbyshire, admired for its varying shades of blue and green, assumes usually the form of a cube; but in other parts the same mineral presents endless varieties of crystalline forms. The metals present themselves under geometrical forms. Native gold and silver occur in small octahedrons, and iron and copper are occasionally found in cubes of great regularity. Silver and copper may be readily obtained in these respective forms by precipitation from their solutions, under certain circumstances, in the electro-chemical process of electrotyping. The crystalline texture of zinc, bismuth, and antimony is readily seen on any of their fractured surfaces. The metallic ores are nearly all crystallized; and even mountain masses, like trap, &c., have a crystalline form. A piece of white marble presents an aggregation of minute crystals, and granite is an aggregation of crystals of quartz, felspar, and mica. The first notion of the crystalline structure is that of a spontaneous arrangement among the constituent particles of the solid so formed, by which the manner of adhesion of every particle is determined. But this implies that while the particles are submitting themselves to be bound up by the aggregating force, they have freedom of motion. The first step towards obtaining a substance in its crystalline form is generally to produce this mobility of the particles, which the chemist usually effects either by solution in water or by the application of heat. A quantity of pounded nitrate of potash (saltpetre), dissolved in water, yields a solution in which the saline particles may be regarded as dispersed throughout the fluid, and having perfect mobility; if the quantity of water be considerable the particles will be too far asunder to exert reciprocal attraction, they will be more powerfully attracted by the water than by each other, and no aggregation will take place. When, however, the water is slowly abstracted by evaporation, the saline particles are gradually brought within the range of each other's attraction, and finally become aggregated, producing regular solids, which on examination are all of the same definite form, a six-sided prism. If, instead of withdrawing the water slowly, the consolidation is hastened, the crystallization takes place in a confused manner; and if the solution be continually agitated during the evaporation, only a fine crystalline powder is obtained. It is by this latter process that nitre is prepared for the manufacture of gunpowder in France, instead of by grinding. Similarly in a solution of sugar, when slowly evaporated and left for some time at rest, the particles arrange themselves in the well-known form of sugar-candy; but when the process is hastened or disturbed, the result is the confused crystallization of loaf-sugar. Common culinary salt, by analogous treatment, may be made to assume the form of regular cubes, and of the powdery form of basket-salt.

Fig. 1.



In cases of igneous fusion similar conditions are recognized; the melted substance must be slowly cooled, and at the same time undisturbed by motion. If bismuth be melted and allowed to cool again slowly and at rest, it becomes solid first on the outside of the mass; if, before the cooling is completed, the remaining liquid portion be poured from within, the interior of the solid hollow mass will be found beautifully studded with four-sided pyramids, connected together at their bases. Crystals of lead, zinc, antimony, sulphur, and of some sulphides, as those of bismuth and antimony, may be readily procured in the same way. Other substances, when heated, readily assume the state of vapour, and during condensation present regular crystalline forms; examples of this are iodine, benzoic acid, camphor, and sal-ammoniac. In this way, also, crystals of snow are produced by cooling the aqueous vapour of the atmosphere.

Although few of the crystallizations that are performed by nature have been imitated by art, the chemist can effect the

crystallization of a vast number of substances which are not found crystallized naturally; and, taking advantage of this circumstance, he is able to obtain them in a state of greater purity than any other method could afford. To the chemist the crystalline characters often serve as a ground of distinction between the different artificial products, as they do in mineralogy to distinguish one mineral species from another.

Most crystals which are formed from aqueous solutions retain a portion of that fluid; this is called their *water of crystallization*. Its proportions vary according to the nature of the salt which is crystallized. Thus sulphate of soda (Glauber's salt) and some analogous salts contain considerably more than half their weight of water. This is seen by subjecting such a salt to a high temperature, when it will liquefy in its own water, undergoing what is termed the *watery fusion*. Sulphate of lime (gypsum), again, contains about a fifth of its weight of water, which it loses at a red heat, and crumbles down into the white powder called the plaster of Paris. This water appears to be in a state of chemical combination with the salt, and not simply interspersed as water through its substance; in almost all cases where it is present the crystalline structure is destroyed when it is withdrawn. There are some salts in which the affinity appears to be feeble, and which part with their water of crystallization by simple exposure to a dry air, or *effloresce;* the crystals crumble away to powder, and entirely lose their peculiar characters and forms. Common carbonate of soda is an example of an efflorescent salt, and a similar effect is observable in the case of barley-sugar. There are, again, salts which manifest an opposite tendency; they *deliquesce* or attract water from the atmosphere when openly exposed. There are other salts, again, which form beautiful and transparent crystals, without containing any water of crystallization. Nitre, sulphate of potash, and common salt are examples of this class. But although they do not seem to combine chemically with water, they often retain it mechanically diffused in their pores. Salts of this class generally fly to pieces with a crackling noise, or *decrepitate* when heated.

Crystallization is sometimes determined in a solution by apparently slight and almost inappreciable circumstances. A mere vibration of the liquid is often sufficient to commence the process. This is particularly remarkable in the case of water. This liquid, if kept perfectly at rest, may be cooled down considerably below the freezing point without consolidation; but under these circumstances, to touch the surface with the point of a pin is enough to make the whole spring almost instantly into ice. In saline solutions, the introduction of a solid body—especially a crystal of the same substance—will cause the crystallization to commence; and the foreign body will form the *nucleus* or centre upon which it will take place, provided that body be capable of being wetted by the liquid. Manufacturers avail themselves of this circumstance in the production of sugar-candy, acetate of copper (verdigris), sulphate of copper (blue vitriol), prussiate of potash, alum, &c., crystallized on threads, strings, twigs of wood, and wires.

Atmospheric air seems to have an influence in promoting crystallization in some cases and of retarding it in others. For example, if a glass flask having a long neck is nearly filled with hot water, and as much sulphate of soda added as it will dissolve, and then boiled for a little time, and if while the steam is rushing out (*having removed it from the heat, however*) it be closed carefully with a good cork, the solution may be cooled down in a quiet place without any symptoms of crystallization. But upon withdrawing the cork the air will rush in, and the whole will crystallize almost instantly.

Light also influences the process of crystallization. Thus, if a solution of the salt called acetate of lime be left to spontaneous evaporation, it will slowly travel in arborescent pellicles up the sides of the basin, and gradually proceed down upon the outside; the process not only begins at the side most exposed to the light, but the arborescence continues always most copious on that side. The crystals collected in camphor bottles in druggists' windows are likewise observed invariably to be most copious upon the surface.

Some substances assume, under different sets of circumstances, as at high and low temperatures, two different crystalline forms, and are then said to be *dimorphous*. Sulphur and carbon furnish examples of this curious fact.

It has been found possible to arrange the many thousand different known crystals into six systems, to each of which belong a number of forms having some property in common. The classification of these different crystals is based upon the supposed existence of certain straight lines within the crystal, passing through its central point from side to side, from end to end, or from one angle to that opposed to it. Round these lines, which are termed *axes*, the particles of matter composing the crystal may be conceived to be symmetrically built up. The six crystalline forms arranged on this plan are—

1. The *monometric*, *regular*, or *cubic system*. The crystals of this division have three equal axes, all placed at right angles to each other. The simplest forms of this system are—fig. 2, the cube; fig. 3, the regular octahedron; fig. 4, the rhombic dodecahedron; fig. 5, the regular tetrahedron. Very many substances, both simple and compound, assume these forms, as most of the metals—carbon, in the form of diamond, common salt, potassium iodide, the alums, fluor-spar, iron pyrites, garnet, spinella, &c.

Fig. 2.

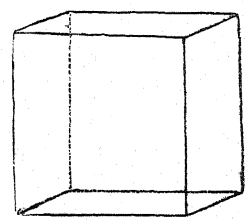


Fig. 3.

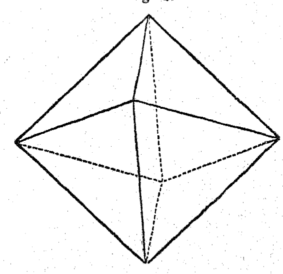


Fig. 4.

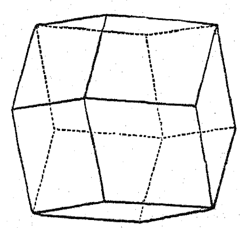


Fig. 5.

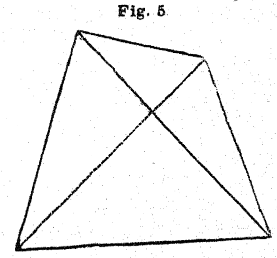


Fig. 6.

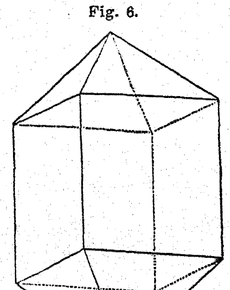
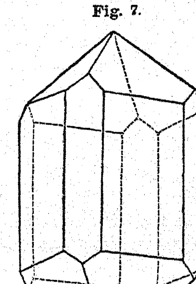


Fig. 7.



2. The *dimetric*, *quadratic*, *square prismatic*, or *pyramidal system*. The crystals of this system are also symmetrical about three axes at right angles to each other. Of these, however, only two are of equal length, the third being either longer or shorter. The simple forms of this system are the first and second right square prisms (figs. 6, 7, and 8) and the right square-based octahedron (fig. 9). Some of the common substances which crystallize in this system are zircon, tin dioxide, yellow prussiate of potash, apophyllite, &c.

3. The *rhombohedral* or *hexagonal system*. This is very important and extensive. It is characterized by four axes,

three of which are equal to each other and in one plane, forming with each other angles of sixty degrees, while the fourth or principal axis is perpendicular to them all. The principal forms are the regular six-sided prism (fig. 10); the regular

Fig. 8.

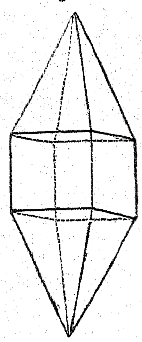


Fig. 9.

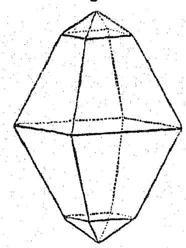


Fig. 10.

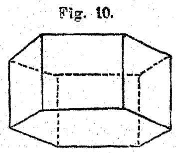


Fig. 11.

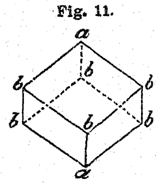


Fig. 12.

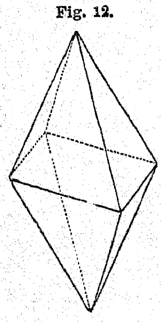


Fig. 13.

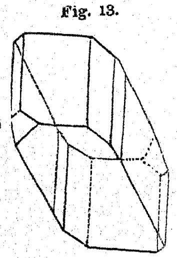
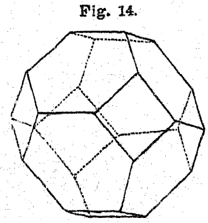


Fig. 14.



six-sided double pyramid; the rhombohedron (fig. 11); and the scalenohedron, a figure bounded by twelve scalene triangles. Examples are found in ice, snow crystals, calc-spar, sodium nitrate, quartz or rock crystal, beryl, graphite, corundum; and the semi-metals, arsenic, antimony, and tellurium. A common form of the quartz crystal is a combination of the regular six-sided prism and double six-sided pyramid.

4. The *trimetric* or *rhombic system* is characterized by three axes of unequal lengths, and all at right angles to each other, as in the right rectangular prism, the right rhombic prism, the right rectangular-based octahedron, and the right rhombic-based octahedron. The perspective forms of these trimetric prisms and octahedrons are similar to those of the dimetric system. Nitre, barium sulphate, arragonite, topaz, native sulphur, &c., are found in this system.

5. The *monoclinic* or *oblique prismatic system* has also three axes, which may be all unequal; two of these, the secondary, are placed at right angles, the third being so inclined as to be oblique to one and perpendicular to the other. To this system may be referred the four following forms:—The oblique rectangular prism, the oblique rhombic prism, the oblique rectangular-based octahedron, and the oblique rhombic-based octahedron (fig. 12). The bases of these monoclinic forms are identical in form with those of the trimetric system. Many substances crystallize in this system; sulphur deposited from fusion, carbonate and phosphate of sodium, borax, green vitriol, cane-sugar, and many other salts.

6. The *triclinic* or *doubly-oblique prismatic system.* The crystalline forms included in this division are, from their great apparent irregularity, exceedingly complicated. Three axes may be traced, all unequal, and all oblique to each other. The doubly-oblique octahedron and the doubly-oblique prism are the leading forms of this system. The perspective forms are similar to those of the monoclinic system. Copper sulphate, bismuth nitrate, boric acid, potassium bichromate, &c., crystallize under this system. The crystalline form of copper sulphate is shown in fig. 13.

Primary and *secondary* forms of crystallization occur when a crystal increases in magnitude by equal additions on every part; but if this increase is only partial, the newly-deposited particles being distributed unequally, alterations of the form are produced, forming figures which have a direct geometrical relation to that from which they are derived. The modifications which can thus be produced of the original form are exceedingly numerous. Several distinct modifications may be evolved at the same time, rendering the crystal exceedingly complex. (Figs. 14, 15, 16, 17, and 18.)

A curious modification of the figure sometimes occurs by the excessive growth of each alternate plane of the crystal, so that the rest become at length obliterated, and the crystal assumes the character termed *hemihedral* or *half-sided.*

Fig. 15.

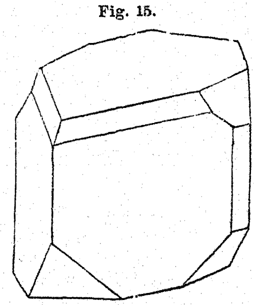


Fig. 16.

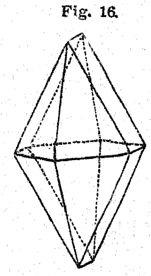


Fig. 17.

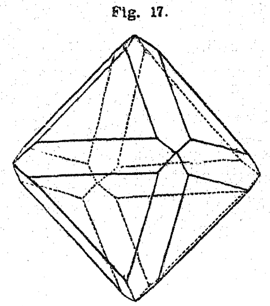


Fig. 18.

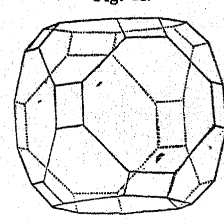


Fig. 19.

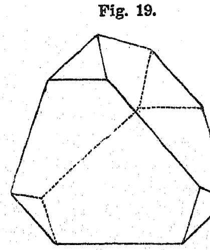
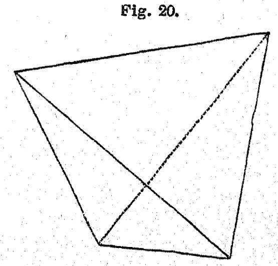


Fig. 20.



The transition from the regular octahedron to the tetrahedron is shown in figs. 19 and 20. Certain substances exhibiting a similarity in their chemical constitution are found to crystallize in the same forms. Such bodies are termed *isomorphous.* When the same body occurs crystallized in two different systems it is said to be *dimorphous.* Crystals not only possess an externally symmetrical form, but their internal structure is likewise regular. Some crystals yield in division in some directions more readily than in others; these directions are called lines of cleavage. The form of the fragments into which crystals can be broken is sometimes the same as that of the original crystal, but in other cases different. Thus in Iceland spar the lines of cleavage are always parallel to the natural planes of the crystal. From carbonate of lime, which crystallizes in a six-sided prism, are obtained rhomboidal fragments similar in form to Iceland spar.

SHORTHAND.—CHAPTER II.

DIRECTIONS FOR PRACTICE.

The student of shorthand should endeavour to gain a thorough knowledge of the sounds of the phonographic alphabet, as given, in the admirable analysis and arrangement of Mr. Pitman, on page 180, and he had better at first confine his attention wholly to the consonants. These should be written out very carefully several times, and continuous practice should not cease until the characters can be made neatly and accurately in any order—downward, upward, as the columns run, and all other possible arrangements. Mr. F. Pitman, of 20 Paternoster Row, has published a copy-book specially suited for this purpose, price 3*d.* or 6*d.*; but when this cannot be readily had any ruled paper may be used. Many who have commenced the study of shorthand have acquired a careless and illegible style of writing it, in consequence of not having given the requisite attention to this first step, which is one of the utmost importance. We strongly recommend that beginners should, when writing, repeat aloud the *sounds* (but not the *names*) represented by the signs. We would also especially urge upon those who really seek success, to note carefully each specific sound and the example of its power as exhibited in their natural order in the phonographic alphabet. For instance,) is pronounced *zee*, not *zed;* has the sound of *way*, not *double u;* and is pronounced *yay*, not *wye*. The character —is pronounced *gay*, and not *jay* or *jee;* that is, it is what is commonly called the hard *g*, as in *go*, *get*, *give*, and never what is called the soft sound of *g*, as in *gem*, *gin*, *age*. The familiar sounds represented by the signs (*ith*, (*the*, *sh*, *zh*, and *ng*, need our most careful attention, as they are not represented in the ordinary alphabet, although they recur very frequently in our most common words and phrases. All the consonants, when standing alone, should be so written as to rest upon the base-line. The liquid *l*, the upstroke *r* (*ray*), the coalescents *w* (*way*), and *y* (*yay*), are written with the upward slant. The horizontal characters — *k*, — *g*, *m*, *n*, *ng*, are written from left to right. All the other consonants are written with a downward stroke; but when joined to other consonants *l* and *sh* may be written either with an upward or a downward sweep. The practical phonographer should accustom himself to write with either pen or pencil. It is better, however, to begin the exercises required with a pencil, which is softer in its gliding and more pleasant and pliable in actual use. When a pen is used, the point ought not to be a broad one. Particular attention requires to be given to the forms of the curved thick characters. They ought to begin lightly and be gradually thickened in the middle only, then tapered off so as to be thin at each end. We would particularly impress upon the earnest-minded student the necessity of zealously observing the recommendation given of drawing the characters with painstaking care for some time, if he wishes in the long-run to become a neat, facile, and graceful writer of phonography.

Having, with increasing carefulness, written out several pages of these consonants, till the hand feels easy in its movements and produces precise results, the student may next proceed to the practice of the joining of consonants, in the course of which he will find the following counsels useful:—

The consonants, when combined to form words, should be written without lifting the pen off the paper or taking any time to raise the hand or alter its position: the second ought to commence just where the first ends, and the third should be continued from the end of the second, &c.

The consonants should, in the earlier stages of the pupil's practice, be written about one-sixth of an inch in length, as they are shown in the specimens in these pages, but as the power of forming them accurately and rapidly increases they may be advantageously reduced in size.

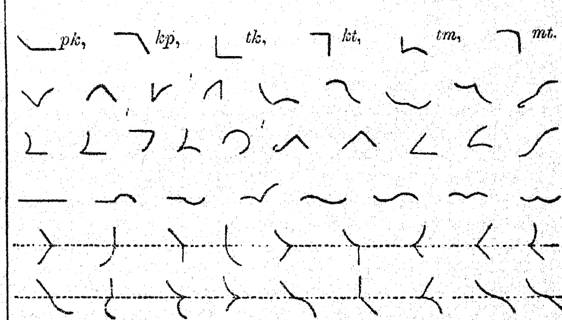
The sign employed to represent letter *l*, when standing alone, is written upward, and that of *sh* downward; thus *l*, and *sh;* but when they require to be joined to other consonants they may be written—as we have already said—either upward or downward, as may be found most convenient for the hand and in the particular combinations which present themselves; thus *lt*, *lm*, *shn*, *shn*.

There should be an angle between *f* and *n*, *f* and *l*, *f* and *m*, and all similar combinations. Beginners in their earlier lessons may make an angle between *p* and *n*, *th* and *n*, and any similar combinations, but the advanced student soon learns to strike these characters quite easily and intelligibly without an angle.

There ought, we may also mention, to be no break made when a consonant formed by a horizontal sign is repeated in the spelling of a word. For instance, *kk* should be written ——, *gg* ——. The doubled length of the line obviously represents the reduplication of the letter. When a curved consonant requires similarly to be repeated the curve should be quite distinctly repeated; thus *ff*, *mm*.

After having, by dint of persistent practice, gained facility in the production of the several consonantal signs, singly and in union, the student should next write out all the possible combinations of consonants which can arise—as an exercise of great utility in effecting expertness and ease. While doing so he should note that combinations similar to those on lines one to four all rest upon the base-line; in those occurring on lines five and six, and all similar ones, the first consonant rests upon the base-line, and the second is written below it.

It will be found promotive of readiness in the reading of phonographic writing afterwards if we get into the habit of writing the names of the consonants for which they stand immediately after each of the consonant-signs, as is done in line one—



The preceding exercise should be written out several times. At first it may be done in large size, and then be gradually diminished at each subsequent repetition. The qualifications to be sought by assiduity of practice are, (1) precise accuracy of form; (2) neatness of execution; (3) facility in producing each sign; (4) readiness and ease in the union of letters; (5) distinct proportionateness in the characters employed in each separate copy made; (6) speed of hand in forming the separate signs and in running them together into clear combinations; and (7) ability to read the signs into letters and sounds at a glance.

We give now a few consonantal combinations, to be written as exercises in a ruled copy-book. Other combinations of a similar kind will readily suggest themselves:—

lp, lch, mp, mf, mth, lm, chch, kk, ll, ksh, kth, fl, ng, trn, mnth, tshp, tlm, brj.

The common letters should in such exercises be written out in alternate lines, and the phonographic translation ought to be written in the interlines, neatly, regularly, and with as much speed of production as is consistent with correctness of form.

The student will have noticed that there are two characters for the letter *r*. The one is called *upward r*, the other *downward r* . Upward *r* and *ch* are similar, but there is little risk of their being mistaken, as is always struck down and is struck up. The upward *r* is struck at an angle of thirty degrees from the horizontal, and *ch* at one of sixty degrees. The lines naturally take these slopes when struck downward and upward respectively. The following are examples:— *tr*, *rt*, *pr*, *rp*, *mr*, *ntr*. When joined to other letters *ch* and *r* are distinguished by the direction of stroke, thus: *chr*, *rch*, *kr*, *kch*, *tr*, *tch*, *mr*, *mch*.

MUSIC.—CHAPTER II.

SECTION I.—SINGING AS AN ART—EFFECTS OF SUPERTONIC AND LEADING NOTE—THE CHORD OF THE DOMINANT—RESTS—TIME STUDIES—MUSICAL EXPRESSION, WITH ILLUSTRATIONS.

THE student who has thoroughly mastered the exercises given in the preceding chapter will find that a new power is being acquired by him, and that new sources of pleasure, enjoyment, and usefulness are being opened. The ability to read even simple music with ease and certainty—to use one's voice naturally, effectively, and without strained effort—is not to be lightly esteemed; and the comparative ease with which it must be felt that these ends can now be accomplished offer further inducements to the continuance of the study of vocal music which can hardly find a parallel in any of the other arts. But however much we may methodize and simplify, endeavouring to make "crooked places straight and rough places plain," we cannot altogether do away with the necessity for individual exertion and earnest application. No royal road to musical knowledge and proficiency has yet been discovered, and from all who would excel, patient, constant, and well-directed effort will be required. As Henry Irving says, "The man who would succeed must work and not dream;" for as Longfellow has it, "Art is long and time is fleeting."

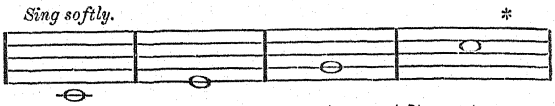
Presuming that our previous instructions have been diligently studied and thoroughly practised, constant care and attention ought now to be directed towards the formation of a good musical tone. We should never forget, that if we sing aright our singing will give pleasure to those who listen to us. Every singer should therefore endeavour to produce sounds that are well-pleasing to the ear. This is called *quality* of tone. Good quality is mainly dependent upon the following conditions, viz.:—(1) The position of the body, which, as formerly stated, should be erect, the shoulders down, and the head held naturally; a healthy condition of body is also absolutely necessary to good singing. (2) The proper management of the breath—that which is known as "abdominal breathing," in opposition to what has been styled "collar-bone breathing," is best fitted for vocal purposes. In breathing, the shoulders should never be allowed to rise, and the ribs should be held steadily in an outward direction. (3) The throwing well forward in the mouth of the stream of vocalized air. This should be so directed as to strike against the palate close to the roots of the upper front teeth; the throat and mouth should be freely opened, and the tongue trained to lie flat.

Certain vowels are better suited for use in singing than others. The Italians, for instance, greatly prefer *ah*; we in this country cannot at first, however, use this vowel properly, and frequently it requires to be assisted by *ee*, *a*, *oh*, and *oo*.

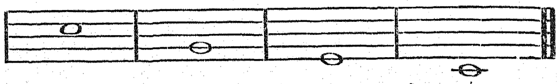
The student's daily exercises should now begin with the following, steady effort being made to observe the directions given:—

Exercise 19.—DOH ON FIRST LEDGER LINE BELOW.

Sing softly.



{ | d :—|—:— | m :—|—:— | s :—|—:— | d' :— |— :— ||
Oh ah a (as in fate) ee



{ | d' :—|—:— | s :—|—:— | m :—|—:— | d :—|—:— ||
oh ah a ee

The same exercise may be sung at a higher or lower pitch, as best suits the voice, but all straining and any harshness of tone should be carefully avoided.

The syllable *koo* sung softly yet sharply gives a shock to the glottis, and greatly assists in the attainment of beauty of tone and ease in singing. In *kooing* the mouth and lips should be much in the same position as if we were about to whistle, but rather more softly rounded, so that, instead of a whistling, a soft singing sound is produced. Proceed to *koo* thus—

Exercise 20.

{ | d :d | d :d | m :m | m :m | s :s | s :s | d':d' | d':d' }
Koo koo koo koo, &c.

{ | d':d' | d':d' | s :s | s :s | m:m | m:m | d :d | d :d ||

EFFECTS OF SUPERTONIC AND LEADING NOTE.

The practical exercises which were given in Chapter I. were all constructed from the tonic chord, consisting of the notes Doh, Me, and Soh. The tone of the scale next to be studied finds its place about midway between Doh and Me, and is called *Ray*, or sometimes the supertonic (see modulator, page 175). Let the student master the following exercises, endeavouring in their course to feel fully the effect of Ray, noticing particularly how vastly it differs from each of the tones previously introduced. As in former exercises, we use only the initial letters in sol-fa. Certain letters of the alphabet are used in music to denote the pitch of different key-tones. This matter will be fully explained later on in the course; meantime it may be useful for some students to have the key-name given in connection with the exercises as exhibited in the sol-fa notation.

Exercise 21.—DOH ON SECOND LINE.

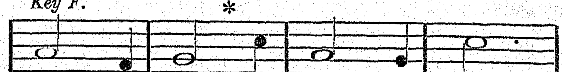
Key G.

{ | m:d | s :d | r :— | m :— | m:s | d :m | r :— | d :— ||

Observe, in the following, that Ray is set alternately on strong and weak accents, with three-pulse measure:—

Exercise 22.—DOH ON FIRST SPACE.

Key F.



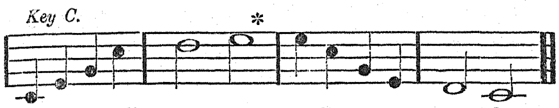
{ | m :— :d | r :— :s | m :— :r | s :— :— }

{ | m :— :d | r :— :s | m :— :r | d :— :— ||

In the next exercise we have the effect of Ray, first high and then low in pitch—

Exercise 23.—DOH ON FIRST LEDGER LINE BELOW.

Key C.

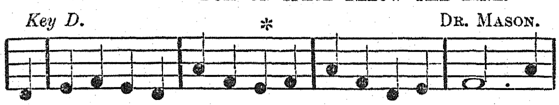


| d :m | s :d' | r' :— | m' :— | m' :d' | s :m | r :— | d :— ||

If the voice dwells upon Ray, we find that a strong desire for another note, usually Doh or Me, arises naturally in the mind. This expectant character of Ray is brought out in the following examples:—

Exercise 24.—DOH ON SPACE BELOW THE LINE.

Key D. DR. MASON.

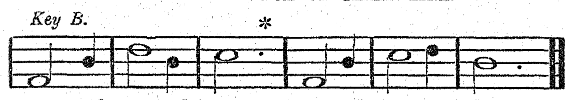


:d | r :m | r :d | s :m | r :m | s :m | d :r | m :— | — :s

| d' :m | s :d | r :m | r :m | s :d | m :r | d :— | — ||

Exercise 25.—DOH ON THIRD LINE.

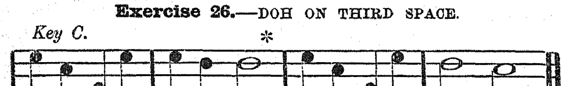
Key B.



| s, :— :d | m :— :d | r :— :— | s, :— :d | r :— :m | d :— :— ||

Exercise 26.—DOH ON THIRD SPACE.

Key C.

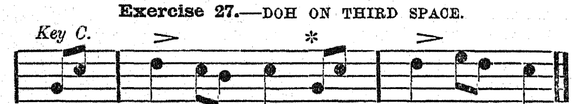


| m' :d' | s :m' | m' :r' | r' :— | m' :d' | s :m' | r' :— | d' :— ||

Mr. T. F. Seward, an American musician, illustrates the restless, expectant, rousing effect of Ray, by giving the following exercise, first with Ray on the prominent accent:—

Exercise 27.—DOH ON THIRD SPACE.

Key C.

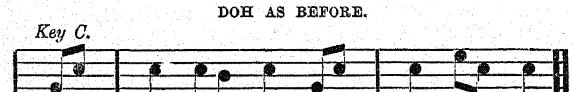


:s .d' | r' :d' .t | d' :s .d' | r' :m' .r' | d' ||

and then, by the substitution of Doh for Ray, produces a contrast which makes the latter note stand out very clearly—

DOH AS BEFORE.

Key C.



:s .d' | d' :d' .t | d' :s .d' | d' :m' .d' | d' ||

Sing the phrase in both ways, so that by actual experience a knowledge of the difference of the effect may be felt.

The tone next to be studied is called *Te*, or sometimes "the leading note," and this finds its natural place immediately underneath and very close to Doh. In characterizing Te, we find that the mark by which it may be best remembered is the constant and ardent desire which it manifests, as one might say, "to get *home*" to Doh. When taken high in pitch, this peculiarity becomes very striking, as its earnestness produces almost a screaming effect; when low, however, it is very tender and pleading.

Exercise 28.—TE FIRST HIGH AND THEN LOW IN PITCH—DOH ON FIRST LINE.

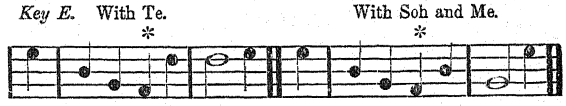
Key E.

| d' :s | m :d' | t :— | d' :— | m :d | s :d | t, :— | d :— ||

Mr. Seward gives the following, first with Te, and then with Me or Soh in place thereof. The student will do well to sing the phrase both ways, taking special care to mark the difference both of tone and feeling:—

Exercise 29.—DOH AS FORMERLY.

Key E. With Te. With Soh and Me.

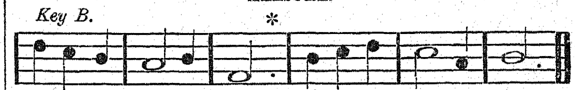


:d' | s :m | r :t | t :— | d' || d' | s :m | r :s | m :— | d' ||

We give a specimen of Te in conjunction with Ray in the two succeeding exercises, viz.:—

Exercise 30.—DOH ON THIRD LINE—THREE-PULSE MEASURE.

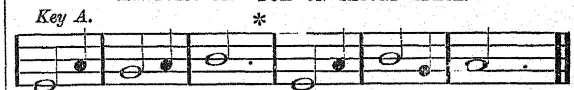
Key B.



| m :r :d | t, :— :d | s, :— :— | d :r :m | r :— :t, | d :— :— ||

Exercise 31.—DOH ON SECOND SPACE.

Key A.



| s, :— :d | t, :— :d | r :— :— | s, :— :d | r :— :t, | d :— :— ||

THE CHORD OF THE DOMINANT.

We have now five tones at our command, each, as we have seen, having a distinctly marked individuality by which it may be known and reproduced. They have been classified and characterized as under, viz.:—

The piercing or sensitive tone,	**Te**	(Leading note).
The grand or bright tone.	**Soh**	(Dominant).
The calm or steady tone,	**Me**	(Mediant).
The rousing or hopeful tone,	**Ray**	(Supertonic).
The strong or firm tone.	**Doh**	(Tonic).

A glance at the modulator (page 175) will show that Te and Ray stand in the same relation to Soh that Me and Soh occupy with respect to Doh; and just as the latter notes make the tonic chord (page 178) so, Soh, Te, and Ray, taken together, form what is called the "chord of the dominant." With these two chords we can make music which is worthy of being united to poetry. But with the introduction of words there arises for the singer a new consideration, in regard to the choice of breathing places.

Good music, like poetry, naturally divides itself into distinct portions, called phrases or sections; and these halting places have hitherto been so marked in our exercises as to make more prominent these natural divisions. The meaning of the words to be sung, however, is now of primary importance, and to this paramount element, what may be called the *sense* of the music has often to give way; although it is obviously the composer's duty to see that these coincide as much as possible.

We recommend the diligent study of the following exercises, observing particularly the breathing places, and attending

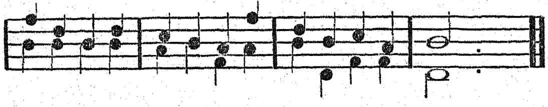
carefully to the production of tone. Most of them, as will be seen, are arranged in "two-part harmony:"—

Exercise 32.—DOH ON THIRD LINE.

Key B. J. SNEDDON, Mus. Bac.

:s_1 |d :t_1 |d :r |m:—|—:d|r :d |t_1 :d |r :—|—:r
:s_1 |m_1:s_1 |m_1:s_1 |d:—|—:d|s_1 :m_1|s_1 :d |t_1:—|—:t_1

A - wake and sing the song Of Mo - ses and the Lamb; Tune
Sing of his dy - ing love. Sing of his ris - ing power, Sing,

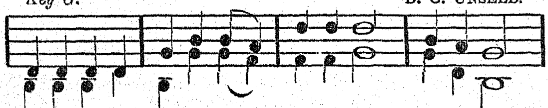


|s :m|d :m|r :d |t_1 :s |m :d |r :t_1 |d :— |— ||
|d :d |d :d |t_1 :d |s_1 :t_1 |d :m_1|s_1 :s_1 |m_1 :— |— ||

ev - 'ry heart and ev - 'ry tongue To praise the Sav-iour's name.
how he in - ter - cedes a - bove For all whose sins he bore.

Exercise 33.—DOH ON SECOND LINE.

Key G. B. C. UNSELD.



|s_1 :s_1 |s_1 :s_1 |d :m |m :r |s :s |s :— |m :r |d :—
|m_1:m_1|m_1:s_1 |m_1:d |d :t_1 |t_1 :t_1 |d :— |d :s |m:—

Sing when first the sun's bright beam, At the dawn, at the dawn,
Sing at noonday, when the sun Rides on high, rides on high,

|s_1 :s_1 |s_1 :s_1 |d :m |m :r |t_1 :d |m :r |d :—|—:—||
|m_1:m_1|m_1: s_1 |m_1:d |d :t_1 |s_1 :m_1|s_1 :s_1 |m_1:—|—:—||

makes the dew-drop dia - mond seem, In the wel - come morn.
and its fer - vid heat we shun, Flooding earth and sky.

The thoughtful student will most probably have observed that at the end of the second and sixth measures of Exercise 33 two notes are connected by a curved line. This is called a *slur*, and it shows that these notes are to be sung to one syllable. The sign for a slur in the tonic sol-fa method is a line drawn underneath the notes.

The next two exercises are called *rounds*, and are to be sung in two parts. In singing these, the second voice waits until the first has reached the note marked thus *. The second voice then commences at the beginning, and carefully observing time and tune, both voices proceed together in harmony. The piece may be repeated *ad libitum.*

The dots which are seen at the beginning and the end of these exercises indicate that the music lying within these dots is to be repeated.

The letters *D.C.* are the abbreviation generally employed on sheets of music for the Italian words *da capo*, from the beginning.

Exercise 34.—DOH ON SECOND LINE—ROUND, IN TWO PARTS.

Keg G. JAS. SNEDDON, Mus. Bac.

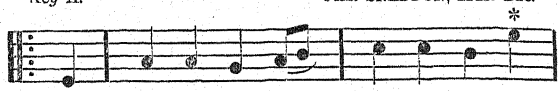
|m :r |d :r |m :s |s :r |m :r |d :m |r :r |m:—
If you trust be- fore you try, You may re - pent be- fore you die

D.C.

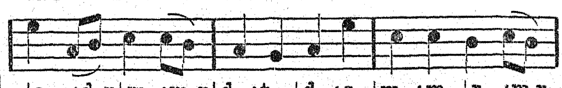
|d :s_1 |m_1:s_1 |d :d |t_1 :t_1 |d :s_1 |m_1:d |d :t_1 |d :— ||
If you trust be- fore you try, You may re - pent be- fore you die.

Exercise 35.—DOH ON SECOND SPACE—ROUND, IN TWO PARTS.

Key A. JAS. SNEDDON, Mus. Bac.



:s_1 |d :d |t_1 :d .r |m :m |r :s
From all that dwell be - low the skies, Let



|s :d.r |m :m.r |d :t_1 |d :s |m :m |r :m.r
the Cre - a - tor's praise a - rise. Let the Re - deem-er's

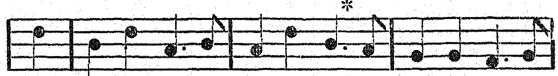
D.C.

|d :d |t_1 :t_1 |d .r :m.f |s :d.r |m :r |d ||
name be sung Thro' ev - 'ry land, by ev - 'ry tongue.

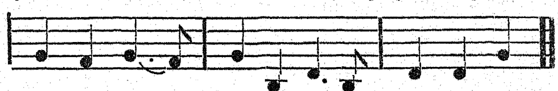
Rounds may be in two, three, or four parts. To sing the next piece properly at least three voices are required. Notice especially the dotted notes—pulse and half in sol-fa.

Exercise 36.—DOH ON SECOND LINE—ROUND, IN THREE PARTS.

Key G. JAS. SNEDDON, Mus. Bac.



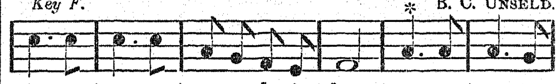
:s |m :s |r :-.m |r :s |m :-.r |d :d |t_1 :-.d
As fair as morn, as fresh as May, Ap- peared young Flo - ra,



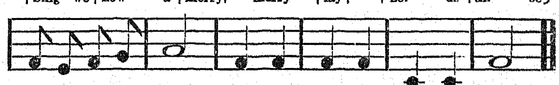
|d :t_1 |d :-.t_1 |d :m_1 |s_1 :-.m_1 |s_1 :s_1 |d ||
bright and gay, War-bling forth a roun - de - lay.

Exercise 37.—DOH ON FIRST SPACE—ROUND, IN THREE PARTS.

Key F. B. C. UNSELD.



|s :-.s |s :-.s |m .r :d .t_1 |d :— |m :-.m |m :-.r
Sing we now a merry, merry lay; Let us all be



|d .t_1 :d .r |m :— |d :d |d :d |s_1 :s_1 |d :— ||
happy while we may, As we jour - ney on our way

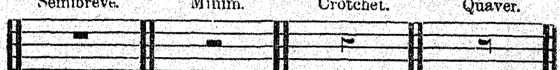
Rests, or pauses for the voice, are, as we have previously stated, often introduced in music, and it is necessary now that the student should become acquainted with those which are most frequently used. Every note has a sign of rest, which shows that the voice is to be silent for exactly the same length of time that would be required to sing that special note. Thus, if a semibreve is to get four beats or pulses, the semibreve rest shows that we are to be silent for such a time as would be occupied in singing the same number. The following table gives the notes hitherto employed, with their symbols for silence, *i.e. rests:*—

Note—

Semibreve. Minim. Crotchet. Quaver.

Rest—

Semibreve. Minim. Crotchet. Quaver.



Square mark *underneath* the line. Square mark *along* the line. Head turned to the *right*. Head turned to the *left*.

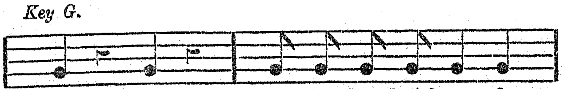
In tonic sol-fa the silent pulses or half pulses, *i.e.* rests, are simply left vacant.

TIME STUDIES.

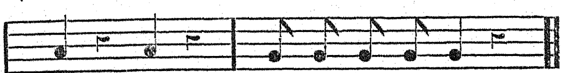
The following exercise should be sung *on one tone.* Let the rests be carefully observed:—

Exercise 38.—DOH ON SECOND LINE.

Key G.



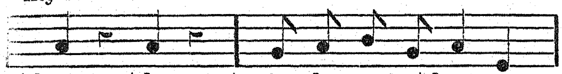
{| d : | d : | d .d :d .d | d :d }
La la la la la la la la



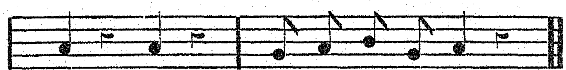
{| d : | d : | d .d :d .d | d : ||
la la la la la la la

We might clothe the above rhythm, or tune-study, with melody thus, singing time and tune:—

Key A. DOH ON SECOND SPACE.



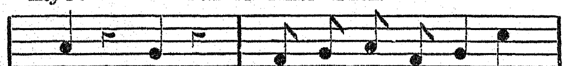
{| d : | d : | t$_1$ .d :r .t$_1$ | d :s$_1$ }
La la, &c.



{| d : | d : | t$_1$ .d :r .t$_1$ | d : ||

Or thus:—

Key F. DOH ON FIRST SPACE.



{| m : | r : | d .r :m .d | r :s }
La la, &c.

{| m : | r : | d .r :m .r | d : ||

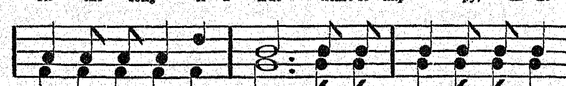
From the above illustrative examples it will be seen that any tune or piece may be studied, first for time alone, the voice not going up or down, and then for time and tune combined. The student will find this course best while learning the following little pieces. Pay attention specially to the crotchet (one-pulse) rests and the slurs:—

Exercise 39.—DOH ON SECOND LINE.

LOOK AWAY TO THE FIELDS.

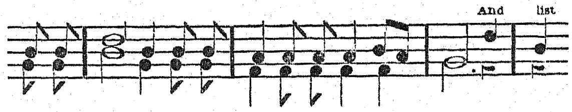
Key G. Adapted from ROOT.

{:m .m | m :m.m | m :m.m | s :— | m :m.m }
{:d .d | d :d .d | d :d .d | m :— | d :d .d }
Look a - way to the fields and the har - vest, See the
'Tis the song of a true heart so hap - py, As he



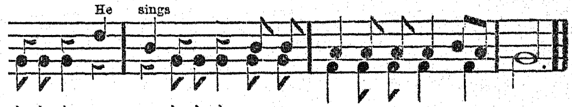
{| r :r .r | r :s | m :— | — :m.m | m :m.m | m }
{| t$_1$:t$_1$.t$_1$ | t$_1$:t$_1$ | d :— | — :d .d | d :d .d | d }
reap - er a - mid the grain; How it rus - tles and trem-
gath - ers the shin - ing store. And he thinks of the soft

And list



{:m.m | s :— | m :m.m | r :r.r | r :m.r | d :— | — :s | m }
{:d .d | m :— | d :d .d | t$_1$:t$_1$.t$_1$ | t$_1$:t$_1$ | d :— | — : }
bles be - fore him Like the rain ripples on the main. And list,
hour of twi - light, When the la - bour of day is o'er. And see,

He sings

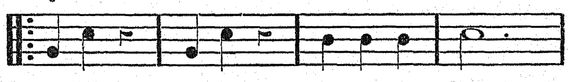


la la la la la la

{: | :s | m : | :m.m | r :r.r | r :m.r | d :— :— ||
{:d.d | d : | :d.d | d :d .d | t$_1$:t$_1$.t$_1$ | t$_1$:t$_1$ | d :— :— ||
la la la, He sings la la la, As he sweeps o'er the gold - en plain.
la la la, He smiles la la la, As his eye seeks the cot - tage door.

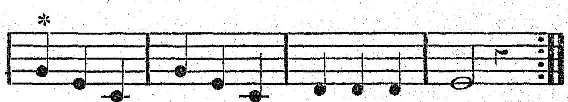
Exercise 40.—ROUND, IN TWO PARTS—THREE-PULSE MEASURE—DOH ON FIRST LEDGER LINE BELOW.

Key C. T. F. SEWARD.



{| s :d^1 : | s :d^1 : | t :t :t | d^1 :— :— }
Cuc - koo, Cuc - koo, list to the song;

*



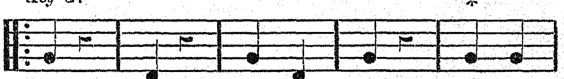
D.C.

{| s :m :d | s :m :d | r :r :r | m :— :— ||
Sweet-ly it floats o'er the mea - dows a - long.

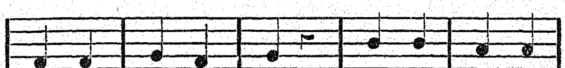
Exercise 41.—ROUND, IN FOUR PARTS—DOH ON SECOND LINE.

B. C. UNSELD.

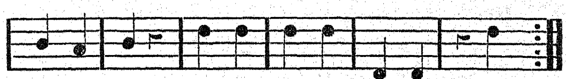
Key G. *



{| d : | s$_1$: | d :s$_1$ | d : | d :d }
March, march, march a - way. Who are



{| t$_1$:t$_1$ | d :t$_1$ | d : | m :m | r :r }
read - y for the fray? Fal - ter not for



D.C.

{| m :r | m : | s :s | s :s | s$_1$:s$_1$ | :s ||
foeman's ire. Now make read - y, aim, and fire.

MUSICAL EXPRESSION.

Expression in music is the art of varying the degrees of force and intensity with which the different tones are struck, and implies the power of uniting heart, voice, and understanding in bringing out the full meaning of both words and music. To have thorough command of vocal expression is the perfection of the singer's art, and this can only be attained by the union of long and careful training, fine natural feeling, and well-cultivated intellect. To expect all this from the student, at the present early stage, might be somewhat too much, but we really cannot too soon begin to aspire after it. The following table gives (1) the names of the different degrees of force, (2) the abbreviations by which they are known, and (3) their definitions. These Italian words, or technical terms, are used for musical purposes wherever music is cultivated as an art:—

Name.	Pronounced.	Marked.	Meaning.
Pianissimo,.	Pe-ah-nissimo, .	*pp*, . .	Very soft.
Piano, . .	Pe-ah-no, . . .	*p*, . . .	Soft.
Mezzo-piano,	Met-zo-pe-ah-no,	*mp*, . .	Moderately soft.
Mezzo, . .	Met-zo, . . .	*m*, . .	Medium.
Forte, . .	Four-tay, . . .	*f*, . . .	Loud.
Mezzo-forte,	Metzo-four-tay, .	*mf*, .	Moderately loud.
Fortissimo, .	Four-tissimo, .	*ff*, . .	Very loud.
Crescendo, .	Cre-shen-do, . .	*cres.* or <,	Increase.
Diminuendo,	Dim-in-oo-en-do,	*dim.* or >,	Diminish.
Swell, ...		<>	Increase and Diminish.
Sfortzando,.	Sfort-zan-do, . .	*sf.* or *fz.* or >,	Explosive.
Legato, . .	Lay-gah-to, . .	. . . .	Smooth, connected.
Staccato, .	Stack-kah-to, .	' ' ', .	Short, detached.
Rallentando,	Ral-lan-tan-do, .	*rall.*, .	Gradually slower.

The *hold* 𝄐 indicates that the tone is to be prolonged at the option of the leader.

Da capo (dah ka-po) or D.C. means repeat from the beginning.

Dal segno (dal seyn-yo) or D.S. means repeat from the sign 𝄋.

Fine (fee-nee) indicates the place to end after a D.C. or D.S.

From the very earliest the endeavour should be to sing rather softly, never, unless for special effect, going beyond a medium force of voice. Turning to the preceding table, we find that *mezzo* is the name and *m* the sign for this degree of power. If we required a sound considerably louder than mezzo, the table informs us that *forte* is the word and *f* the sign required. We might, however, desire a sound a little louder than mezzo, and not so loud as forte; this would be called *mezzo-forte*, and would be known by the letters *mf*. In the same way we might go to *fortissimo*, or, to take the other direction, to *mezzo-piano* (*mp*), *piano* (*p*), or *pianissimo* (*pp*). Study diligently the following exercises on degrees of force, remembering, however, that the pitch ought to be varied as far and as much as the range of the voice will readily permit without strained effort:—

Begin with medium power of voice, and increase gradually to *ff*. This is called *crescendo*, and the sign, as may be seen, is *cres.* or <. Sing to *la* at any convenient pitch—

m mf f ff

Begin again with middle force of voice, and gradually diminish the sound, accompanying each, in thought, with name and sign—

m mp p pp

A combination of these exercises produces the swell—

pp p mp m mf ff f mf m mp p pp

In practising the following illustrative pieces, it would be well to proceed gradually in the four stages suggested below, viz.:—(1) Regard each as a time exercise, studying time and accent alone; (2) sing it over, using the tonic sol-fa syllables; this is called *sol-fa-ing;* (3) sing the exercise to la; and (4) sing the words with great attention to expression.

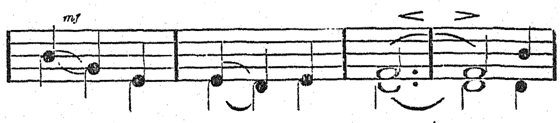
Exercise 42.—DOH ON FIRST LINE—THREE-PULSE MEASURE.

SWEET DAY SO COOL.

Key E. JAS. SNEDDON, Mus. Bac.

{:s |s :— :m |d :— :r |m :— :s |s :— :(s)}
{:d |m :— :d |d :— :t, |d :— :m |m :— :(s)}

Sweet day, so cool, so calm, so bright,
Sweet rose in air, whose od - ours wave, And
Sweet spring, of days and ros - es made, Whose

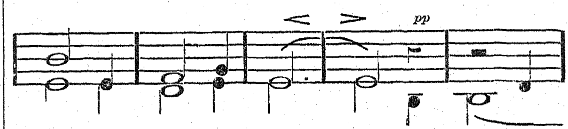


{|s :m :d |d :t, :d |r :—:— |— :— :s}
{|s :m :d |d :t, :d |t, :—:— |— :— :t,}

Bridal of earth and sky, The
col - our charms the eye, Thy
charms for beau - ty vie, Thy

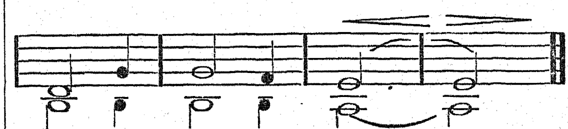
{|s :— :m |d :— :r |m :— :s |d' :— :m}
{|m :— :d |d :— :t, |d :— :m |m :— :d}

dew shall weep thy fall to - night; For
root is ev - er in its grave; And
days de - part, thy ros - es fade; Thou,



{|s :—:d |r :— :m |d:—:— |— :— : | : :t,}
{|d :—:d |t, :— :d |d:—:— |— :— :s, |s, :—:—}

thou, a - las! must die. For thou, For
thou, a - las! must die. And thou, And
too, a - las! must die. Thou, too, Thou,



{|t, :— :m |m :— :r |d :—:— |—:— ||}
{|— :— :s, |s, :— :s, |m, :—:— |—:— ||}

thou, a - las! must die.
thou, a - las! must die
too, a - las! must die.

In the previous exercise a few things occur which require explanation. At the end of the second and fourth lines of words, and again at the finish, two notes have a curved line like a slur drawn over them *across the bar*. This is called a *bind* or *tie*, and shows that the first note is to be *held*, not re-struck with the voice. At the beginning of the second lines of words the two voices sing the same notes; this is called a *unison*. Notice also, at the same place, the alteration of accent required in the second and third verses as compared with the first. The dotted lines (······) show that a slur is only occasionally to be used.

Exercise 43.—DOH ON FIRST SPACE.

BY COOL SILOAM.

Key F. JAS. SNEDDON, Mus. Bac.

{:m |s :m |r :s |m :r |d :t, |d :r |m :d |r:—|—:m}
{:d |t, :d |r :t, |d :s, |m, :s, |m, :s, |d :d |t,:—|—:d}

By cool Sil - o - am's shady rill How sweet the li - ly grows; How
Lo, such the child whose early feet The paths of peace have trod; Whose

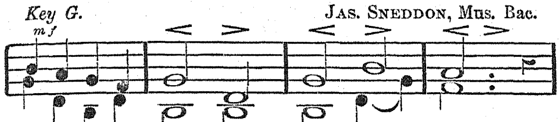
{|s :m |d' :m |r :s |m :d |t, :d |r :t, |d :— |— ||}
{|t, :d |m :d |t, :t, |d :d |s, :m, |s, :s, |m, :— |— ||}

sweet the breath beneath the hill Of Sharon's dew - y rose.
secret heart, with influ - ence sweet, Is up - ward drawn to God.

Exercise 44.—DOH ON SECOND LINE.

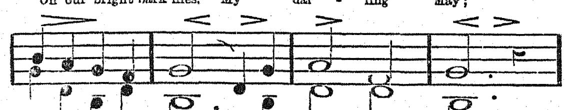
DARLING MAY.

Key G. JAS. SNEDDON, Mus. Bac.



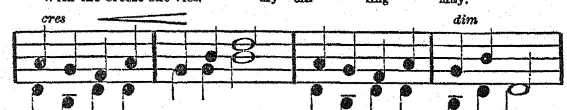
|m :r |d :t_1 |d :— |s_1 :— |d :— |m :— |r :— |— :
|d :s_1 |m_1:s_1 |m_1:— |m_1:— |m_1:— |s_1 :d |t_1 :— |— :

Swiftly o'er the tide, My dar - ling May,
On our bright bark flies, My dar - ling May;



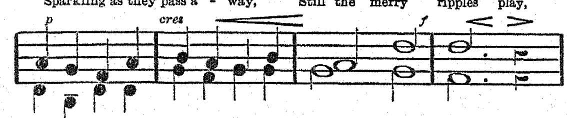
|m :r |d :t_1 |d :— |s_1 :d |r :— |t_1 :— |d :— |— :
|d :s_1 |m_1:s_1 |m_1:— |— :m_1 |s_1 :— |s_1 :— |m_1:— |— :

In our boat we glide, My dar - ling May.
With the breeze she vies, My dar - ling May.



|r :d |t_1 :r |d :m |s :— |r :d |t_1 :r |d :m |s_1 :—
|s_1 :m_1 |s_1 :s_1 |d :d |m :— |s_1 :m_1 |s_1 :s_1 |m_1:s_1 |s_1 :—

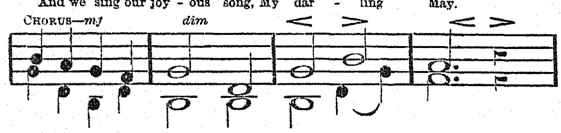
Sparkling on our wat'ry way, See the merry ripples play,
Sparkling as they pass a - way, Still the merry ripples play,



|r :d |t_1 :r |m :r |d :m |r :— |s :— |s :— |— :
|s_1 :m_1 |s_1 :s_1 |d :t_1 |d :d |d :— |d :— |t_1 :— |— :

As we sing our joy - ous song, My dar - ling May.
And we sing our joy - ous song, My dar - ling May.

CHORUS—*mf*



|m :r |d :t_1 |d :— |s_1 :— |d :— |m :— |r :— |— :
|d :s_1 |m_1:s_1 |m_1:— |m_1:— |m_1:— |s_1 :d |t_1 :— |— :

Swiftly o'er the tide, My dar - ling May.

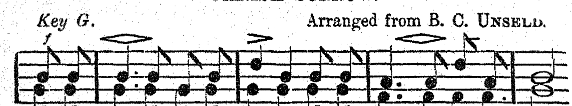
|m :r |d :t_1 |d :— |s_1 :d |r :— |t_1 :— |d :— |— : ||
|d :s_1 |m_1:s_1 |m_1:— |— :m_1 |s_1 :— |s_1 :— |m_1:— |— : ||

In our boat we glide, My dar - ling May.

Exercise 45.—DOH ON SECOND LINE.

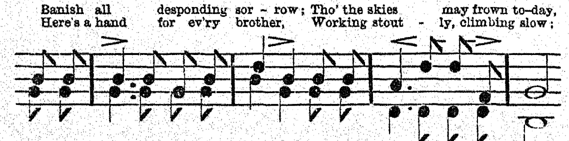
BANISH SORROW.

Key G. Arranged from B. C. UNSELD.



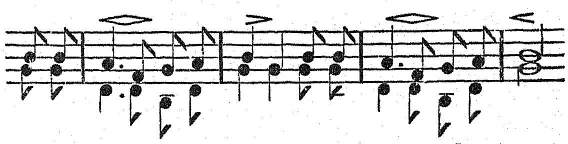
:m.m |m :-.m:d.m |s :m :m.m |r :-.r:s.r |m:-
:d.d |d :-.d:d.d |d :d :d.d |t_1 :-.t_1:t_1.t_1 |d:-

Banish all desponding sor - row; Tho' the skies may frown to-day,
Here's a hand for ev'ry brother, Working stout - ly, climbing slow;



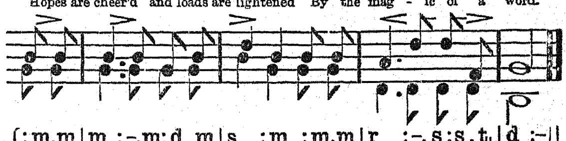
:m.m |m :-.m:d.m |s :m :m.m |r :-.s:s.t_1 |d :-
:d.d |d :-.d:d.d |m :d :d.d |s_1 :-.s_1:s_1.s_1 |m_1:-

Shall not sun - shine with to-mor - row O'er its a - zure beauty play?
Here's a will to help each oth - er In the doubts we all must know.



:m.m |r :-.t_1:d .r |m :d :m.m |r :-.t_1:d .r |m:-
:d .d |s_1 :-.s_1:m_1.s_1 |d :d :d .d |s_1 :-.s_1:m_1.s_1 |d :-

Life must bring its toil and trouble, But the heart that fears and faints
Hopes are cheer'd and loads are lightened By the mag - ic of a word.



:m.m |m :-.m:d m |s :m :m.m |r :-.s:s.t_1 |d :- ||
:d.d |d :-.d:d.d |m :d :d.d |s_1 :-.s_1:s_1.s_1 |m_1:- ||

Makes the heav - y burden dou - ble. Heaping care with vain complaints
Dusky day by smiles is brightened. Ere the friend - ly tone is heard.

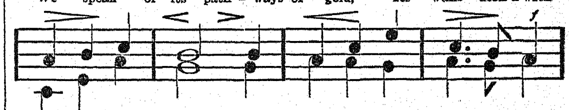
Exercise 46.—DOH ON SECOND SPACE—THREE-PULSE MEASURE.

WE SPEAK OF THE REALMS.

Key A. JAS. SNEDDON, Mus. Bac.

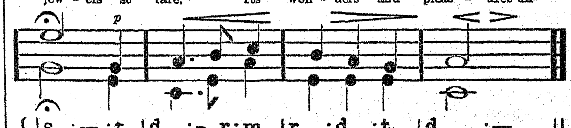
:s_1 |m :-.r:d |t_1 :d :r |s_1 :— :d |r :-.d:t_1
:s_1 |d :-.s_1:m_1 |s_1 :s_1 :s_1 |m_1:— :m_1 |s_1 :-.s_1:s_1

We speak of the realms of the blest, That coun - try so
We speak of its path - ways of gold, Its walls deck'd with



|d :r :m |r :— :r |d :m :s |m :-.r:d
|m_1 :s_1 :d |t_1 :— :t_1 |d :d :t_1 |d :-.t_1:d

bright and so fair, And oft are its glor - ies con-
jew - els so rare, Its won - ders and pleas - ures un-



|s :— :t_1 |d :-.r:m |r :d :t_1 |d :— ||
|t_1 :— :s_1 |m_1 :-.s_1:d |s_1 :s_1 :s_1 |m_1 :— ||

fess'd; But what must it be to be there?
told; But what must it be to be there?

Exercise 47.—DOH ON SECOND LINE.—THE VALE.

Key G. JAS. SNEDDON, Mus. Bac.

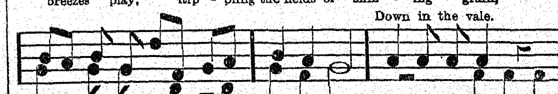
|d .t_1:r .d |t_1 :d |r.d:r.m |d :— |m.r:m.d |r :s
|m_1 :m_1.m_1 |s_1:m_1 |s_1 :s_1 |m_1 :— |s_1 :d .d |d :t_1

O'er all the smiling vale be - low Soft - ly the sum - mer
O'er all the smiling vale be - low Soft - ly the sum - mer

|t_1 :r |s_1 :— |d .t_1:r .d |t_1 :d |r .d:r m |d :r
|s_1 :s_1 |s_1 :— |m_1 :m_1.m_1 |s_1 :m_1 |s_1 :s_1 |d :t_1

shadows stray, Tint - ing with deeper, fair - er green
breezes play, Rip - pling the fields of shin - ing grain,

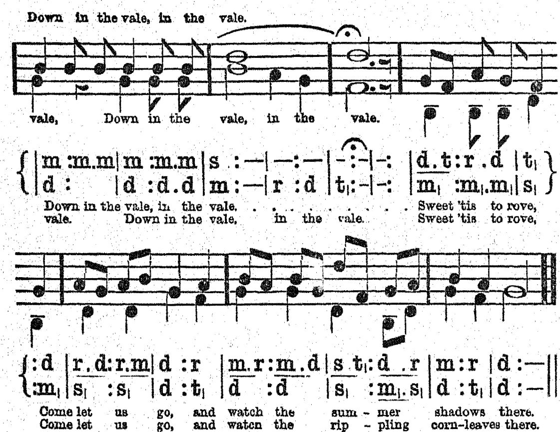
Down in the vale.



Down in the

|m.r :m.d |s .t_1:d .r |m :r |d :— |r :r.r |r :
|d :m.d |s :m_1 s_1 |d :t_1 |d :— | : |t_1 :t_1.t_1

Mea - dow and field up - on their way Down in the vale.
As o'er their feath-'ry tops they stray. Down in the



DRAWING.—CHAPTER I.

We shall suppose that the student is about to commence the practical study of drawing with no previous knowledge of the subject beyond what has been given in our introductory article. It will, of course, be necessary, in the first place, to provide a few materials. Fortunately, these need be but few, and they are very inexpensive. It is usual to commence to draw on paper with a black-lead pencil, though, as the eminent artist and able lecturer, Benjamin R. Haydon, has said, "Any one who can draw should be able to draw with anything and on anything—even on a wall with a piece of burnt stick." A pencil and paper will be found more convenient than the wall and the charcoal. A fair-sized sheet of cartridge paper and a moderately soft pencil, H.B. or B., should therefore be obtained; it will also be advisable, probably necessary, to have a piece of india-rubber, but this should be used as seldom and as little as possible. Lines ought not to be put rashly down on the paper without thought, under the idea that they can and may be immediately rubbed out again. The india-rubber should not be kept in the one hand and the pencil in the other, and the one used as often as the other. The pencil is to be regarded as an instrument to draw with; the rubber is to be looked on only as an occasional help to remove the errors which almost all beginners ordinarily make. These errors ought to be as few as possible; and rubbing out should, as a rule, be avoided by exercising as much care as can be in all that we do. Caution may do much to prevent error; precaution will aid us in lessening the need for using india-rubber.

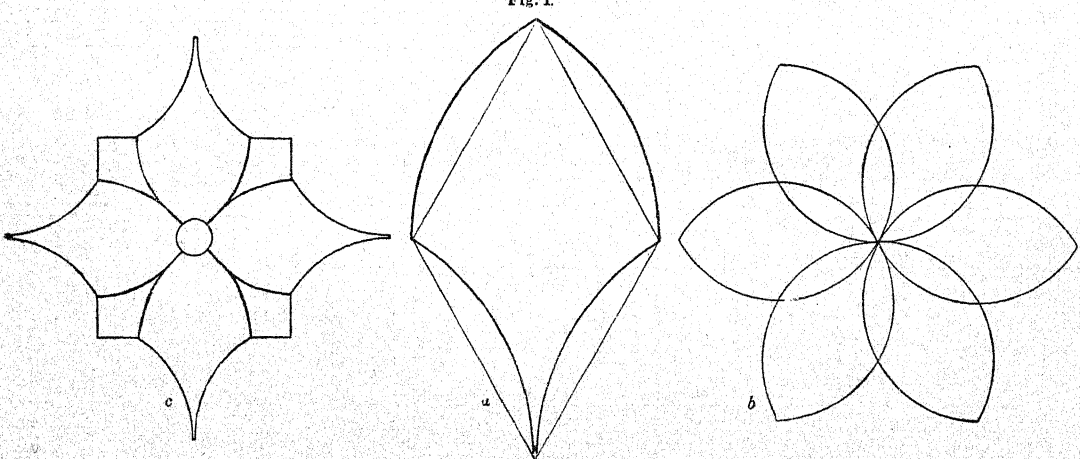
The student, having furnished himself with the necessary implements, will next require something to copy. The first efforts made in drawing must necessarily be imitative, and therefore something to imitate must be provided. For many years it has been thought necessary for this purpose to print special ornamental forms, called "drawing copies." These drawing copies, now to a large extent abandoned, are practically excluded from good schools of art. Even the student who attends no school—except that of self-improvement—can, it has been found, almost do without them too. They are not by any means absolutely necessary, and in some cases they are worse than useless. The great demand for such copies has created a large supply, and many of these are quite as likely to injure as to improve the taste of the student.

It may be, and indeed has been, said that it is not of much consequence what a student copies, as the first thing he has to learn is merely such dexterity of hand as will enable him to imitate correctly a given form; and as this aptitude can only be acquired by an almost endless repetition of a certain series of muscular actions, the student may as well be practising on one form as another until such skill is attained. But drawing is not a mere series of purely physical actions; it is a mental process also. The mind may, and in fact ought to be, trained at the same time as the hand. It is very desirable, therefore, that the most suitable examples possible should be placed before the student, even from the beginning.

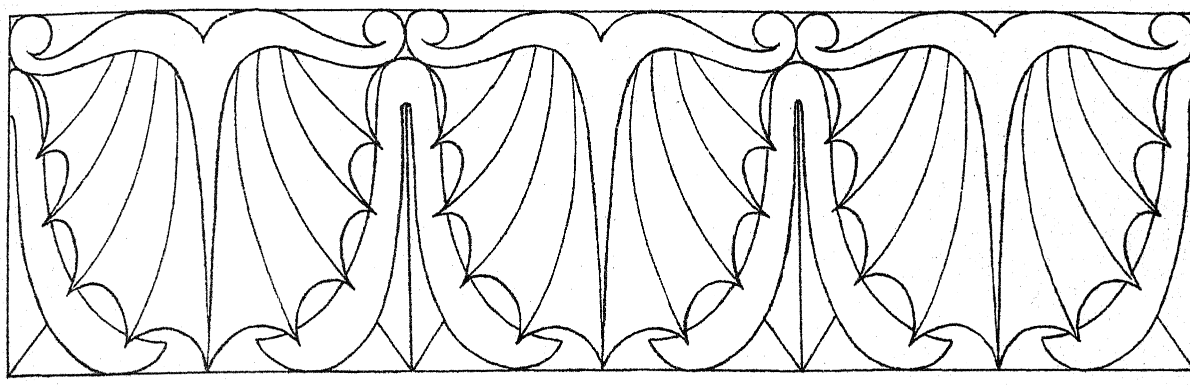
How much of this mere copying work should be done by students, and how long they should be kept at drawing from the flat, are matters undergoing much debate just now, some high authorities asserting that very little, if any, copying should be done, whilst the Science and Art Department demand that a student should pass a rather difficult examination in this division of the subject before going on to higher work. There can be no doubt about the fact that this merely imitative drawing from copies, as it has not unfrequently been conducted in our schools of art and elementary drawing classes, is wearisome and discouraging. On the other hand, it is equally certain that for young students and beginners it is by far the most convenient and practical method of training the eye to appreciate and the hand to imitate form.

It is quite evident that, within the limits to which we must confine ourselves in these pages, it will be impossible to give a series of such examples, sufficiently numerous and varied, to satisfy the desires, perhaps the wants, of an eager copyist. We shall adopt another, and, as we think, a better course. An elementary form will first be given. The student will next be shown how to repeat this once and again in new aspects, and also combine with it other similar forms. This mode of procedure will not only enable him to continue his practice for the acquisition of trustworthy capacity of hand,

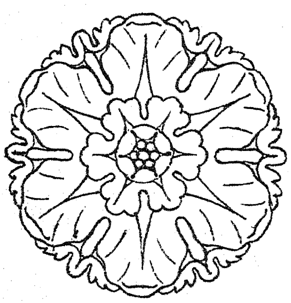
Fig. 1.



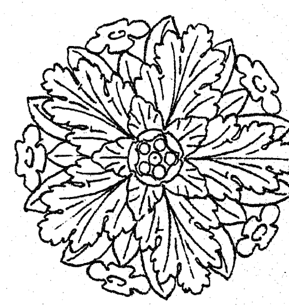
but will impart to this usually wearisome work a new interest, and give the observant student some idea of how ornament is constructed or designed. We will take first the simple elementary form shown at *a* in fig. 1. It is nothing more than a rhomboid or lozenge-shape, with a piece taken off the bottom and added to the top; yet it is possible to make an almost endless series of combinations with it, as shown at *b* and *c* in the same figure, and at fig. 2.



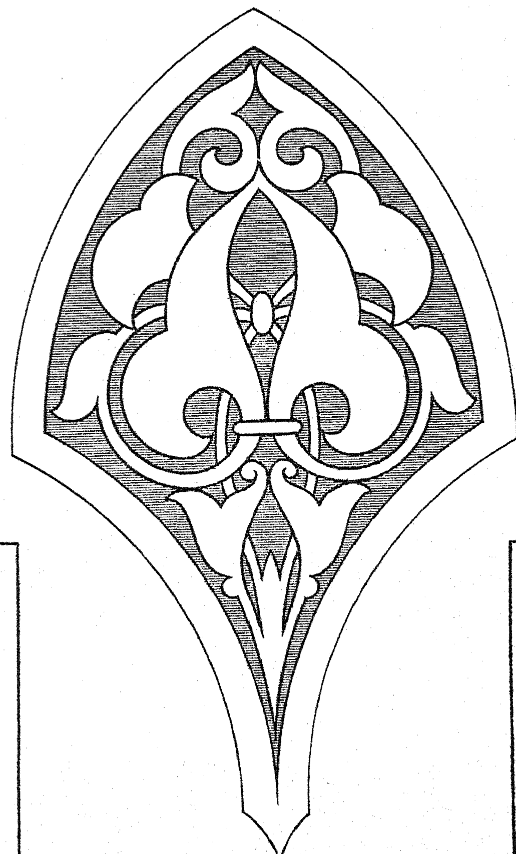
1. Greek border.



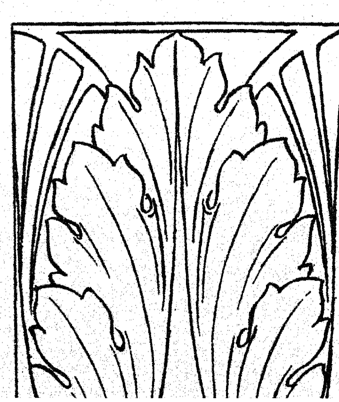
2. Roman rosette.

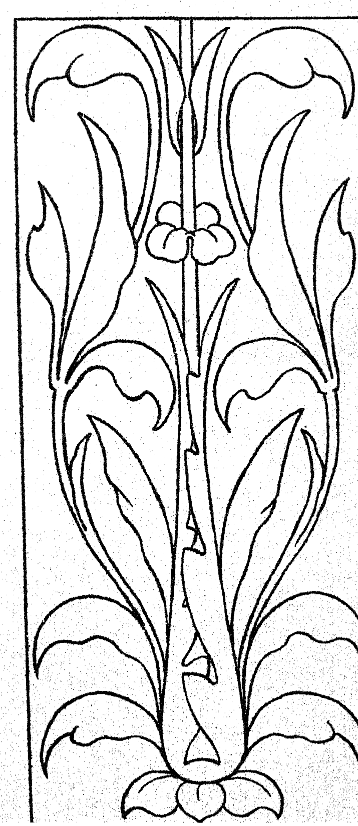


3. Roman rosette.



4. Moresque pattern.





The student, after carefully drawing the elementary form and the combinations here given, should attempt any other combinations he may find himself able to construct, remembering that the special work he has at present to do is to get (1) the *curves* rounded rightly; and (2) the spaces inclosed by them of exactly the same proportion, although his drawing may be, as it may advisably be, varied from size to size, till it be made, for instance, three or four times as large as the examples here given.

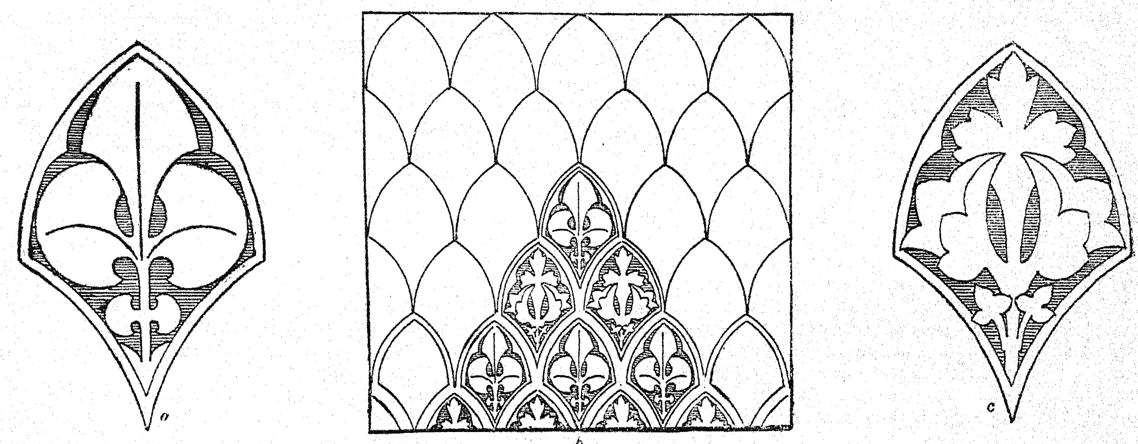
After having repeated this elementary form in such various ways as suggest themselves, until his patience and ingenuity are exhausted, the student may turn to Plate II. and there see the clever way in which the Moors, who built the palace of the Alhambra at Granada, in Spain, 500 years ago, used this form for the decoration of the walls of that "Red Castle" of the Moorish monarchs. When, by dint of practice, he has obtained some facility in producing fair copies, he should task himself to draw out the elementary form presented above as large as this page is, and try to put into it the Moresque pattern shown in Plate II. fig. 4.

All the drawings done from these examples should be large, not less than 6 inches high in any case; the sheet of drawing paper used ought not to be crammed with work. As a rule, not more than two drawings should be put on one sheet. By attending to this direction the paper can be kept clean, and the drawings on it can be made neat and clear, as well as true.

It will be found, in practice, best to start with the most elementary example, and not put away the copy until by diligent care and persevering effort it has been made as good as the student can make it; then it ought to be put away carefully, never destroyed. All drawings should be thus preserved; and there should not be one among them that he need be ashamed of, if he combines in his efforts watchfulness of eye, skill of hand, and activity of mind. A piece of ornament inclosed in a form such as that shown at *a* and *c*, fig. 2, is less difficult to draw than one which is not so inclosed, for the student is able to note the points in the form at which the ornament touches it or approaches it closely. It is very desirable also to notice the shapes of the spaces left between the elementary form and the lines of the ornament. By getting into the habit of carefully noting these things, the student will be better able to fit the ornament into the shape of the inclosing form, so as to leave no disproportionate spaces.

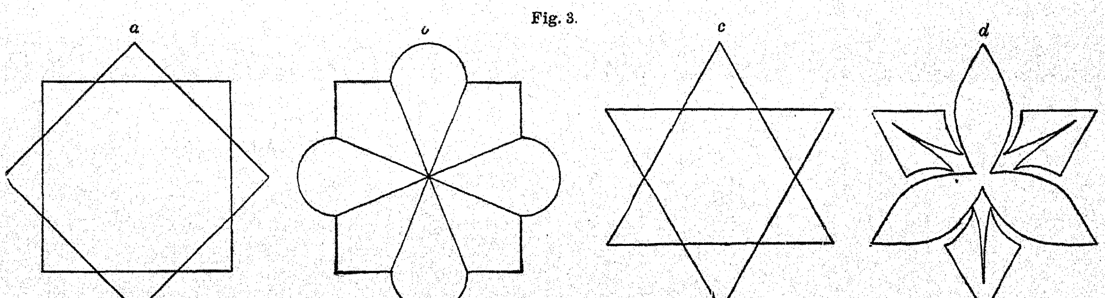
In all good design it will be found that the *spaces* both covered and left will be equally distributed, one of the laws or principles of ornament being *equal distribution of space.* The Gothic artists in our own country also used the abovementioned form, and in fig. 2 some examples are shown of the way in which it was combined and filled up by them; the combination in the centre is called a *diaper*, and was used for the decoration of large flat spaces on walls. The student, after he has copied the diaper pattern on a large scale, by taking the two examples of filling up the space which are given in fig. 2, and alternating them until the whole space is covered, will have an excellent series of exercises, as he will also have if he will draw out one or two other elementary forms and try to fill them up himself with ornaments similar to, but not quite like, those in the figure.

Fig. 2.



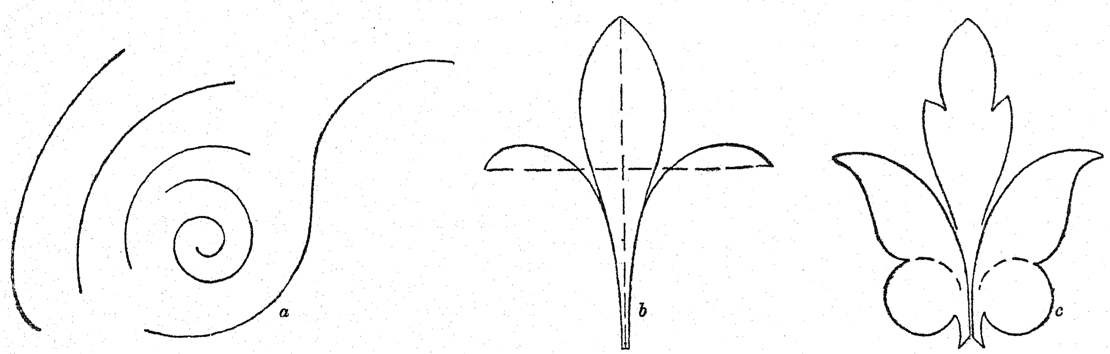
In fig. 3 we supply, as specimens, two other forms, the square and the triangle, both of which are capable of many combinations. The examples *b* and *d* should be copied, the intersecting squares and triangles upon which they are evidently founded being first lightly but carefully sketched. Then the two squares and the two triangles should again be drawn out, and an endeavour should be made to invent other patterns, the squares and triangles forming the foundations. Another of the principles of ornament is shown in the above sketches—the principle of *alternation*, a pointed form being alternated with a rounded one; and in endeavouring to devise new forms this principle should be followed. Like all other true principles of ornament it is founded upon nature, and the student will find endless suggestions, which will be far better than drawing copies, by looking at the backs of flowers and observing the wonderful and beautiful way in which the sepal of the calyx is made to alternate with the petal of the corolla.

Fig. 3.



Elementary students will probably find great difficulty in drawing the curves or curved lines, which form the most

important part of all ornamental design. This difficulty arises, not so much from the want of mechanical skill—which is sure to be obtained by sedulous practice—as from want of knowledge; it is possible to make beautifully fine individual curved lines, yet the curves themselves be bad. It is therefore necessary to know something about curves, how they are constructed, and what makes them good or bad. Curved lines are of various kinds. The student should carefully study their various characters and the differences between them. The simplest form is that in which the curve is part of a circle. In the best ornament, other and more subtle curves are used; the Greek curves are almost invariably parts of an ellipse. Examples of curved lines are given at *a* in fig. 4. These differing curves should be copied several times over, and ought not, in fact, to be given up until the difference between them is so evident as to be seen at a glance. The combination of these curves with each other, and with straight lines, constitutes a very important part of decorative design. The mere drawing or copying of these combinations is always a difficulty with the



elementary art-student. It takes much care, exercised for a long time, to learn the difference between a good curve and a bad one, and much training of the eye and hand in concert before it is possible to make one of the more subtle of these curves with ease.

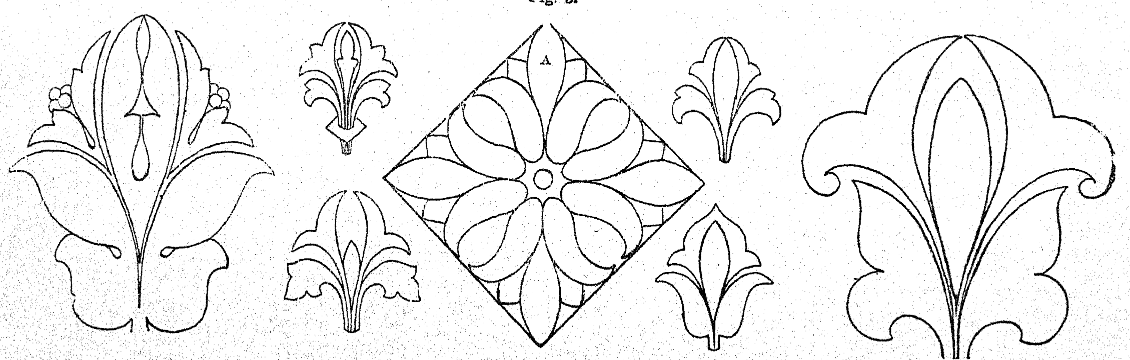
A well-known story is told of the great painter Giotto, to the effect that when the Pope wanted him to do some painting in St. Peter's, at Rome, the holy father sent a messenger to Giotto and told his Internuncio to bring back a specimen of the artist's skill. The message being delivered, Giotto took up a pencil, and, with one sweep of his hand, described a complete circle. He told the messenger to take back that as an example of what he could do. The Italians still say, when they describe anything perfect, "It is round as Giotto's O."

To be able to make a perfect circle, or any complete and perfect curve, with ease and certainty, shows that the hand and the eye have had much continuous training and years of assiduous and daily practice. It is not to be wondered at, therefore, that beginners find great difficulty in forming these curves. To combine them is even more difficult, for the union of curves with curves requires always to be so made as to give the appearance of growth or radiation. The lines should meet at a tangent, that is, as just touching each other at the joining or point of union, so as to give a graceful growing out of line from line. Now, at the place where the lines unite, beginners and unpractised hands are apt to make the curves look as if one would run through the other instead of merely joining it. *Radiation* should be the principle upon which all curves are united with curves or straight lines. The word is rather long and learned looking, but the meaning is easily enough understood when explained. It means that all the curves should *radiate*, or appear to grow out from one *radix* or root. A simple example of this principle is given at *b*, fig. 4. This should be copied in a large size, an upright straight line being used in the centre to aid in the balancing of the curves and getting the spaces inclosed by them of the proper shape; a horizontal line will also be found useful, and special care should be taken with the joining of the curved lines. When these curves are correct and the lines clear, an effort should be made to add such other lines as would make a complete ornamental form, such as that shown at *c* in same figure.

Many other ornamental arrangements might be founded on these elementary curved lines by addition and repetition, and the student should now attempt some of these combinations, a few examples of which are shown in fig. 5.

This repetition of simple forms is chiefly recommended for the purpose of affording practice in drawing curves correctly and clearly. It can hardly as yet be called designing, although it will be an introduction to that part of our subject when it will fall to be treated of at length. Therefore, whenever the student attains that point of practical skill at which a fairly

Fig. 5.



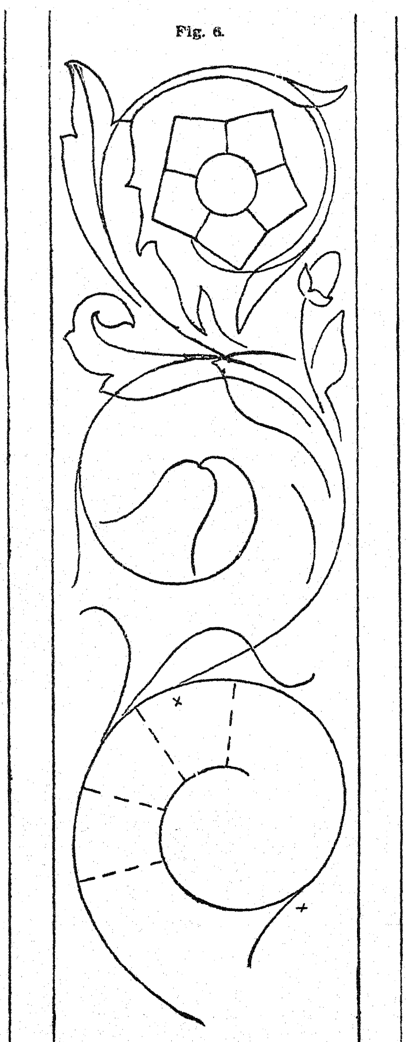
satisfactory form can be made by a repetition of three or four of the elementary shapes, as shown at A in fig. 5; this form may be again repeated and alternated with another, so as to make a fresh diaper pattern similar to the one shown at *b* in fig. 2.

We now proceed to take a far more difficult subject. A large amount of decorative work is composed of foliated scrolls of various kinds. Such scroll-work is seen in almost all Roman decoration, and after the decline of classic art it was again largely used in the Renaissance period—that era in which classic art was revived, or was, as the word *renaissance* means, born again.

The French and Italian buildings of the fourteenth, fifteenth, and sixteenth centuries were profusely decorated with this kind of ornament. It is usually called Acanthus scroll-work, because the curves or scrolls are clothed or covered with a leaf similar to that of the acanthus plant.

This classic and renaissance decoration is very beautiful, and has, in later times, been frequently imitated, so that it is hardly possible to copy drawings without meeting with these difficult but attractive forms. An example of this acanthus

Fig. 6.



foliage is given in the annexed cut (fig. 6), and it will be as well for us to take some trouble to analyze this, and to show the best way to set about the imitation of it. First, we have the scroll or main line of the ornament, which should be drawn as a simple continuous line, carried right through the details. This main line should have no angles or corners; the space inclosed by parts of the scroll should be carefully noted, as at × ×, and the joining of one scroll to the other ought to be done with accuracy and grace. A few other leading lines might then be added, and finally these elementary lines, clothed or decorated with the foliated forms, commencing by *blocking out* the larger divisions, as shown at the upper portion of the cut.

A small piece of acanthus leaf is drawn in Plate II. fig. 7, and it will probably help the student, if we show him how to block out this one leaf. First, sketch lightly the outer shape; then draw upon it a line following the outside line, and indicating the "eyes" or divisions of the lobes of the leaf; then draw the boundary lines of these divisions, finally filling in these block forms with the small delicate details of the edge. These various stages are sufficiently shown at *b*, fig. 7, and the more accurate shape of the edge is exhibited in larger drawings at *a* and *c* in the same figure. The lines upon the leaf should all radiate or grow out of the mid-rib or central line.

It will be seen from these instructions that the best method of copying drawings is, broadly, as follows:—First, find out the leading line or backbone, as it may be called, of the drawing to be imitated; after this is carefully drawn, seek for and search out the offshoots, or next most important lines. Plenty of time should be devoted to the correct drawing of these, and the relation they bear to the main line must be strictly observed. The principal masses of the detail should next be taken—the spaces inclosed by the lines of the ornament, and the spaces left between, being carefully compared with the original. Lastly, when all is as perfect as the student can make it, the detail is to be added in. If the details be left until this last stage, there will be little doubt about their being in the right place, and the whole of the attention can then be given to the minute drawing required at the finish. On the other hand, if the student commences with detail, as is unfortunately too often the case, it is almost inevitable that the drawing when finished will be found to be wholly wrong in general form.

Hundreds of "freehand" papers worked at the government examinations are immediately cast aside by the examiners, because they see at a single glance that the proportion or general form is incorrect; the laboured detail, upon which the student has spent the larger part of the time allowed for examination, is never even looked at; and rightly so, for if the *proportion* is wrong no amount of finish can make the drawing even passable. Too much importance is frequently given to this matter of finish by students in all stages of their elementary education, and even experienced artists sometimes overload their drawings or their canvases with unmeaning finish. Mr. Ruskin says that we should "demand no refinement of execution where there is no thought, for that is slaves' work unredeemed. Rather choose rough work than smooth work, so only that the practical purpose be answered, and never imagine that there is reason to be proud of anything that can be accomplished by patience and sandpaper."

The "practical purpose" to be answered by the study of the elementary examples here given is to get ability to imitate form, and therefore too much importance should not be attached to finish. That which is called (and very badly called) "lining in," or the act of going over the lines of a drawing, is often an injury rather than an improvement to the work; some students get the impression that the lines are to be made *blacker*, and ask the question, "Shall I darken this now?" This impression is wholly wrong—black lines are not by any means desirable; if a drawing is gone over again at all, it should be with the object of making it *better*, not blacker —the thickness or the thinness of the line being of small importance in comparison with the beauty and accuracy of the form.

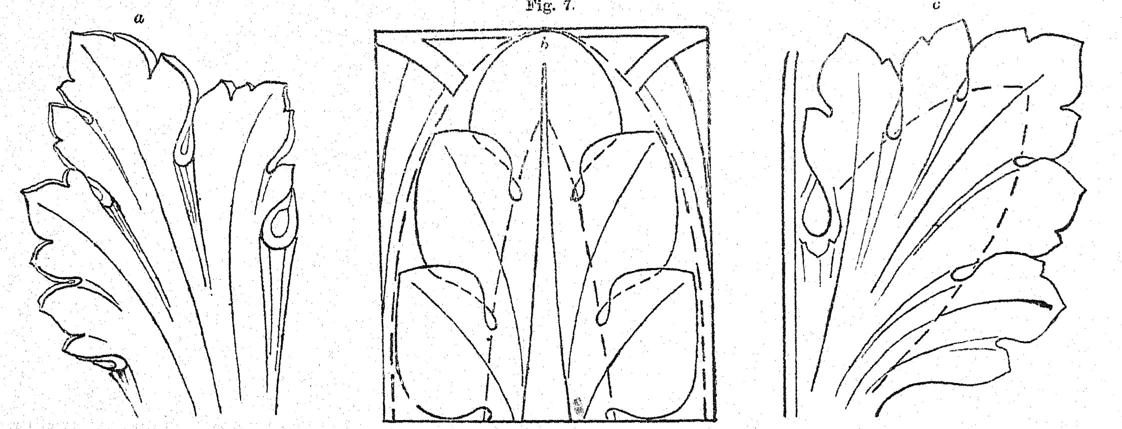
It must be admitted that this freehand drawing, that is, the continual copying of other drawings, is a somewhat unattractive portion of the student's work. It may be compared to the scales in music, and requires almost, if not quite, as much study and practice. To avoid the monotony of constant repetition, it will be well to alternate freehand with model drawing or drawing from objects, instructions for which will be given in our next chapter.

The example in Plate II. fig. 4 is in the Moresque or Saracenic style, and is from the wall decoration of the Alhambra Palace in Spain. This decoration is flat or in very low relief, and enriched with colour and gilding. When the student has made a good copy of this he should try to pick out the ground by a series of fine horizontal lines, as shown in the Plate; or if he is ambitious, as every student should be, he may separate the ornament from the ground by two washes of colour—one light all over, and one darker on the ground. For this purpose a tender colour, such as *yellow ochre* or *terre verte*, should be used.

Many of the elementary drawings done by the student at this stage might be tinted as described above. It will be a commencement in the way of brush-work, and it will better enable the student to distinguish the spaces or masses of the

ornament. This is most important, as all drawings, and indeed, all things, may be said to consist of more or less numerous *spaces* of various shapes and dimensions, either bounded by lines or divided from each other by shades or colours, and the comprehension and imitation of these spaces is all-important to the student of drawing. If much difficulty is found in laying on these flat tints, and the student does not like to run the risk of spoiling a good drawing in outline by putting a bad wash of colour on it, let him first practise on a clean sheet of paper in the following manner:—Draw a square or rectangle about twice the size of this page, divide it into nine other rectangles by lines drawn across it vertically and horizontally; mix three tones of one colour—a light tone, a darker, and a darker; put a flat wash of the light tone on the top left-hand space, on the next below a darker tone, and on the lowest a full dark tone. Then begin the next row of

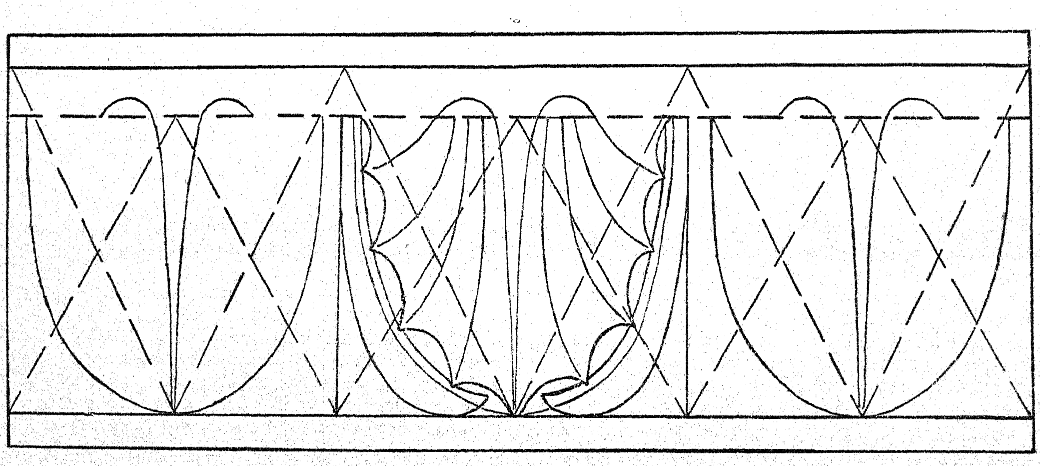
Fig. 7.



rectangles, beginning at the top with the darkest tone, and finishing at the bottom with the lightest; perhaps it would be well to leave a narrow space of white paper between the rows of rectangles. When using the colour the paper should be slightly inclined, so that the tint will run down; the brush should be kept full, and the colours *washed* on, not painted or rubbed on. When the bottom of the space is reached the superfluous colour should be taken up with a dry brush or piece of blotting paper. This operation should be repeated many times, until the student is able readily to fill the given spaces with a perfectly flat wash, that is, of one even tone all over. More elaborate exercises of this kind will be suggested as we proceed in the course.

The scroll pattern forming fig. 6, Plate II., is in the style of the Renaissance, and has been sufficiently described in the preceding pages. The drawing forming fig. 5 is in the same style, and forms part of the decoration of the tomb of Louis XII. in St. Denis, at Paris. This tomb is a very beautiful specimen of the art-work of the period; it is surrounded by a number of small pilasters or narrow flat pillars. These pilasters are covered with beautiful delicate carving, and the drawing here given is a copy of a portion of one. The Greek border (fig. 1) at the top is called a "leaf-and-tongue" border, and is an excellent specimen of ornamental construction by means of repetition and alternation. In attempting to copy it the student should commence by blocking out the pattern, as shown in the woodcut. The two circular drawings, figs. 2, 3, Plate II., are called "rosettes," and are in the Roman style. These rosettes were generally carved in high relief, and used frequently in the decoration of classic buildings. In copying these examples a circle should first be drawn and divided into as many parts as there are leaves in the rosette.

It is impossible to give a sufficient number of examples to keep an industrious student long employed in copying them; but he ought to, and we hope will, exercise his own ingenuity to the utmost in inventing new shapes for himself, and after-



wards employ himself in combining and copying them again and again for the sake of practice. When this fails he may find numerous suggestions in other books, even though they may not be specially art-books. The patterns on wall papers, carpets, curtains, and the like, afford ample scope for copying skill. Above all, let the true student go to nature. The book of nature is the best of all drawing-books, and in it may be found examples enough, and suitable enough, for all and sundry. The child can copy the simple outlines of leaves or flowers. When these are set in infinitely varied position on a spray or a bough, they form a study for a trained student; and when they are all mingled together with thousands of other such forms in the glorious profusion of nature, it is hard indeed for the most skilful artist to imitate one-half of the rare and delicate beauties they present to the eye that possesses the power of "seeing," on which all success in art depends.

TRIGONOMETRY.—CHAPTER III.

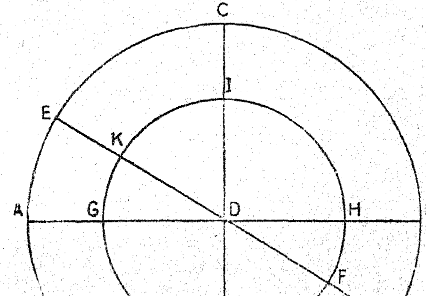
GEOMETRICAL AND ALGEBRAIC TRIGONOMETRY—CHARACTERISTICS AND FUNCTIONS OF ANGLES—EQUAL AND SIMILAR TRIANGLES—SOLUTION OF TRIANGLES.

THE trigonometrical formulæ presented in the previous chapter may perhaps have excited a sense of difficulty in the mind of the thoughtful student, for, in them, we have somewhat outrun the points demonstrated in the foregoing matter. These formulæ are, however, so useful for reference and as gains, if firmly lodged in the memory, that when we were giving a few we thought it better to place the more important before our readers at once. A greater difficulty, however, than that may also have suggested itself—viz. how, having begun with geometric figures and magnitudes, have we transformed our signs and conceptions of these magnitudes into algebraic expression? This is an important question, and would require considerable space to answer it fully and scientifically. Luckily, it is not necessary for us here to retrace the long and arduous course of the history and development of the higher mathematics. It will be enough, at present, to state that the deficiencies of the ancient notation for number and magnitude caused the consideration of the processes employed in the investigation of magnitudes to be pursued almost wholly by the methods of geometry. Now, however, when we have acquired a system of notation by symbols so complete that the most delicate and refined relations of magnitude can be expressed and reduced to simple symmetrical formulæ, even geometry is largely pursued and extended by the use of algebra. So much is this the case that algebraic geometry is a name now not uncommonly given to the application of algebra to the solution of geometrical problems. In a similar manner algebraic trigonometry has been developed, and become one of the most important branches of analysis. In it geometrical magnitudes have become trigonometrical functions, and these again have been transformed into numerical quantities, having certain definite relations to each other, so that the angular functions and the circle are regarded as submultiples and multiples of each other, and, through a thorough knowledge of its modes and results, trigonometry in its primitive elementary form has been vastly extended in range and improved in power and process. A few sentences may enable us to show this.

It must be kept clearly in mind that it is on *angles*, not on *arcs*, that trigonometry is, properly speaking, based. But it has been found that any angle at the centre of a circle which is subtended by an arc equal to the radius of a circle, is the same for all circles. Hence the circular measure of an angle, as has been explained, is that number which expresses the *ratio* of the arc which subtends it to the radius of the circle. This is expressed in the equation, $\text{Angle} = \frac{\text{arc}}{\text{radius}} = 57{\cdot}2958$, or $A = \frac{a}{r} = 57{\cdot}2958$, *i.e.* the circular measure of the angle. This circular measure may be used as the representative of (1) an *arc* of a circle which is the same length as the radius; or (2) the *angle* subtended by that arc, because these are equal one to the other. It may be used, therefore, as a unit to measure other angles or arcs; for example, if in an angle the length of the subtending arc is half the length of the radius, we would have $A = \frac{a}{r} = \frac{1}{2}$ of $57{\cdot}2958$, *i.e.* $28{\cdot}6479$. Again, if an arc be three times that of the radius then we should have $A = \frac{a}{r} = 3 \times 57{\cdot}2958 = 171^\circ{\cdot}8874$. Sometimes, on account of this measure depending on the mutual correlation of arc and radius, the phrase "radian measure" is used as a synonym for "circular measure." This radian measure, it is obvious, may be taken as *unity*, and so the old geometrical definition of a line may be transformed into a *ratio*. The radius as a line is fixed as a *ratio* in value, though it has not a fixed value as a line—*i.e.* it may be of any (indefinite) length, but, whatever its length, its ratio to the arc which subtends it is fixed. To obviate the inconvenience of this varying length, the *line* as a measure has been superseded by the *function*. In this way it happens that if the radius is taken as a line, we must use a sign, as r, for its value, so that if $\mathit{sin}\ A$ denotes the perpendicular line in a right-angled triangle, and $\mathit{sin}\ A$ the ratio of perpendicular divided by hypothenuse, we would have $\sin A = \frac{\mathit{sin}\ A}{r}$, or $\mathit{sin}\ A = r \sin A$. If the student tries thus to express each of the sides of a right-angled triangle in the terms of the other side, making use of the trigonometrical ratio, he will find each side and each angle can be so expressed, and that therefore the geometrical can be changed into an algebraical expression.

It is a somewhat severe task, even for people who are quite in the habit of thinking on what they have undertaken to study, to bring their minds to a clear perception of trigonometrical *ratios* as equivalents for linear measurements. There seems to them to be a reality about *lines* that does not belong to *ratios*. How can such things be as "magnitude of angle," "unit of angle," &c. There are, indeed, two species of "unit of angle:" (1) that employed in the actual observation of angles, and currently as well as correctly adopted in the practical applications of trigonometry—viz. the ninetieth part of a right angle; and (2) that made use of in the regular work of theoretical trigonometry—viz. the angle subtended at the centre of any circle by an arc equal to the radius. Here we use not *lengths* but *ratios*—the ratios (or proportions, one relative to another) of two lengths; and these constitute the trigonometrical *functions* of the angle. Two angles are said to be equal when one can be placed on the other in such a way that their sides coincide simultaneously one with another. All right angles are therefore equal, and hence the right angle forms an invariable magnitude to which all other angles can be referred, and with which they may be compared. It is easily seen in the diagram (fig. 1) that

Fig. 1.



the angle at D is the same in magnitude in B D C and in H D I; that the angles B D C and A D C are equal; that the length of the meeting lines has no influence upon the angles, which are precisely the same in H D I and G D I. It is also clear that the angle at the vertex D is quite the same in magnitude for the meeting lines G D, D K, as for the longer ones A D, D E.

Continuing our examination of the same figure, we can easily perceive that the arc G K is similar in its proportion to the angle at D as the arc A E; so with K I and E C, I H and C B, K H and E B. Still further, we shall see that in the same or in equal circles equal angles intercept equal arcs; as, G D I and I D H intercept equal arcs of G I F, and A D C and C D B intercept equal arcs of A E B. Similarly G D K and H D F intercept equal arcs of G I F, for two arcs of the same radius are equal when one can be so placed upon another that they in all points coincide. It follows from this also that equal arcs are subtended by equal angles. So it is that the arcs H I (B C) being equal to the arcs I G (C A) are subtended by the equal angles H D I (B D C) and G D I (A D C), and H F and G K being equal arcs have the equal angles F D H and G D K subtending them.

Exercise.—Examine the accompanying diagram (fig. 2), and point out (1) the complement and supplement of the arcs E B, (2) the complement and supplement of C E, and (3) the supplement and complement of the angles E G B and C G F, A G F and C G E.

It is interesting to know the origin of the names given to

the trigonometrical functions. Of course these were introduced when *lines* were used; but they have been retained as technical terms, although in modern usage they mean *ratios* rather than lines. We present the following diagram (fig. 3), on which we hope the student will endeavour to trace as he proceeds the several lines meant, and remember their names:—C A B is an angle at the centre of a circle subtended by the arc C B; the line C E, drawn from one extremity of the arc perpendicular to the line A B, is called

Fig. 2.

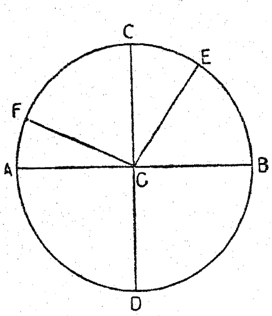
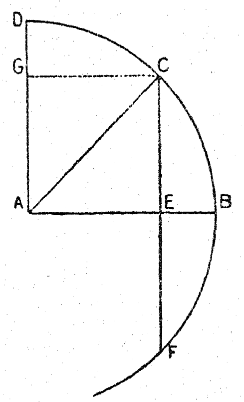


Fig. 3.



the *sine* of the opposite angle C A B, or of the arc C B; because the arc C B F was thought of as a bow (Lat. *arcus*), the line C E F, joining the extremities of C B F, was regarded as the string or chord (Lat. *chorda*) of the bow, and the upper part, C E, being that which was drawn by the bowman to his breast, was called the *sine* (Lat. *sinus*, the bosom). It is easy to see from this figure that the chord equals two sines. Hence, as we have seen already, the cosine of an angle is equal to the sine of the complement of the angle, and the sine of an angle is equal to the cosine of the complement of the angle. Fig. 3 will enable us to see that "the sine of an arc is half the chord of double that arc;" for let the arc C B=B F and be signified by a, then the arc C B F is equal to $2a$, and the radius A B bisects the chord C E F at right angles (Euc. III. 30), therefore C E=sin A. Hence chord $2a=2 \sin a$; and this is memorized thus, A=2 sines $\frac{1}{2}$ A. By the same process it may be seen that the line C G is the *sine* of the angle D A C, which is the complement of C A B. It is also equal to A E, and hence it is called the *cosine* of C A B, *i.e.* the co-equal and companion sine. In this way we see plainly (1) that if the hypothenuse A C is regarded as radius, the perpendicular C E is the *sine*, and the base A E the *cosine* of the angle A at the centre; and (2) that if the hypothenuse A C is the radius, the perpendicular C G is the sine and the base A G the cosine of the angle at the centre A. The part E B, which constitutes the radius A B *minus* the cosine of C A B, was called the *versed* sine, or other end of the sine; while G D—that is, the radius A G D minus A G—is called the *coversed* sine of C A B. The *versed* sine of the supplement of an arc is called the *suversed* sine, contracted into *suvers.*

The *angle*, as a magnitude, has a characteristic which distinguishes it from all other magnitudes. It is, as pointed out in p. 184, *the only magnitude which is a function of a number, and of which a number is a function.* An angle, when given, determines ratios of lines, and so determines number. There is one ratio of arc to radius, one sine, one cosine, &c., to one angle, and all these are numbers. This unique characteristic gives value to angular measurements, and the ratios which arise thence as functions. Any species of relation becomes a magnitude so soon as it can be shown that the notion implied in any one or other of the three words indicative of magnitude—equal, greater, or less—invariably arises from the consideration of any two such fixed and definite relations. A simple example may illustrate this:—If the three sides of any triangle, A B, B C, C A, are respectively equal to 3, 4, and 5, then B C=$\frac{4}{5}$ of A C; B C would be the sine of C A B—not $\frac{4}{5}$ of any line or any line regarded as $\frac{4}{5}$ of a unit, but simply $\frac{4}{5}$ of an abstract unit agreed on by convention to represent the hypothenuse of any triangle.

The trigonometrical functions of an *arc* depend on the magnitude of the radius, and the lines which are the trigonometrical functions of an arc correspond, as we have said, to certain ratios which are the trigonometrical functions of an *angle;* but the functions of the angle are independent of the magnitude of the radius (as was fully explained in Chap. I., p. 96).

Every triangle consists of *six* parts, viz. three sides and three angles. There are also three independent relations which necessarily exist between these parts, so that, in general, in any triangle of which three parts are given, the remaining three parts can only have one set of relative values, and these are in distinct ratio one to the other; as, A+B+C=180, and $\frac{\sin A}{a}=\frac{\sin B}{b}=\frac{\sin C}{c}$.

The reader may be referred for the proof of the determination of the relative values of several of these parts of triangles to Euclid I., propositions 4, 7, 8, 26, 47, &c., but it will be found useful here to collect the results and present them to the eye in a tabular form:—

Two triangles are

I. Equal, which have	II. Similar, which have
1. Two angles and the adjacent side *equal.*	1. Two angles *equal.*
2. One angle and the containing sides *equal.*	2. One angle and the containing sides *proportional.*
3. Three sides *equal.*	3. The three sides *proportional.*

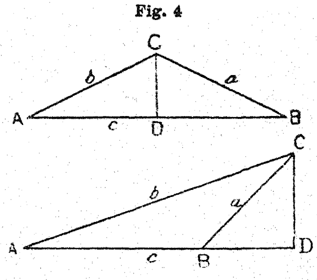
A triangle can only have *one right angle;* hence the two acute angles are *complementary.*

No triangle can have more than *one obtuse angle.* Hence any angle of a triangle is *supplementary* to the sum of the other two.

In the solution of triangles the following distinct cases may arise:—

I. *Right-angled,*	II. *Oblique,*
when the given parts are	
1. Two sides.	1. Three sides.
2. One side and the hypothenuse.	2. Two sides and their contained angle.
3. One side and the opposite angle.	3. Two sides, and an angle opposite to one of them.
4. One side and the adjacent angle.	4. One side and the two adjacent angles.
5. The hypothenuse and an angle.	5. One side, its opposite angle, and one adjacent angle.

Fig. 4



We can see now that the *sides* of any triangle are proportional to the sines of the opposite angles. Let A B C (fig. 4) be a triangle, and $a\,b\,c$ the sides of the same. From C draw C D perpendicular to A B (or, if necessary, to A B produced). Of the first figure, angles A and B are both acute, and in the second A is acute and B obtuse. Therefore in either

$$(1)\ \sin A=\frac{CD}{b};\ \sin B=\frac{CD}{a}\ \therefore\ \frac{\sin A}{\sin B}=\frac{a}{b};$$

and as included in the same formula and clearly deducible from them,

$$(2)\ \frac{\sin A}{\sin B}=\frac{a}{c};\ \text{and}\ (3)\ \frac{\sin B}{\sin C}=\frac{b}{c}.$$

Euclid I. 32 proves that "the three interior angles of every triangle are equal to two right angles," and this gives

the equation (already exhibited) $A+B+C=180$. Hence, if any one of the acute angles of a right-angled triangle is known the other is known also, for it is its complement to a right angle; *e.g.* The acute angle at the base of a triangle is 79·48—what is the acute angle at the vertex? *Ans.* $90^{\circ}-79{\cdot}48=10^{\circ}{\cdot}12$.

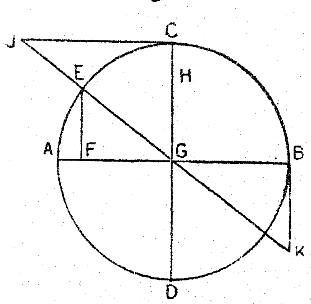
From Euclid I. 47, if any two sides of a right-angled triangle be given the third can be easily known; *e.g.*

If the hypothenuse = 3965 and the base 3172, the perpendicular = 2379; thus

$$\sqrt{3965^2+3172^2}=2379.$$

The student will find it advisable to examine the annexed diagram (fig. 5), and to accustom himself to tell off speedily and accurately (1) the sine, versed sine, tangent, and secant of the arc E A; (2) similarly of the arc A C; (3) the cosine, coversed sine, cotangent, and cosecant of A E; and (4) similarly of A C. After having done this, let him construct the figure similarly in each of the other quadrants and endeavour to understand what each of the lines are named, and why they are so named. It will tend greatly to the student's comprehension of the subsequent operations if he will carefully notice in all these lines those which conform to the necessary and sufficient conditions of proportionality or ratio, in so far as regards (1) correspondence in equality, (2) correspondence in sum. It may sometimes, of course, be convenient to speak of the sum or product of two *lines*, but this expression, as now used, really signifies the sum or product of the *numbers* which represent these lines when measured by some common unit. It requires to be remembered, too, that any two lines (or magnitudes) will be proportionate (1) if any two values of the first, which are equal, correspond to two equal values of the second; and (2) if the sum of any two values of the first corresponds to the sum of two similar and corresponding values of the other. Hence it follows that, in all triangles, (1) the equality of the angles involves the proportionality of the sides, and (2) the proportionality of the sides that of the angles.

Fig. 5.



THE HISTORY OF GREAT BRITAIN AND IRELAND.—CHAPTER II.

THE MAKING OF A NATION—THE HEPTARCHY—ENGLAND.

Self-reliant development is impossible under the rule of foreign oppressive power. For five centuries Roman conquerors and colonists had interfered with the healthy natural growth of the British people. Under the impulse of self-preservation the Latin legions were withdrawn; and the island which they had weakened by repression, as well as kept divided by their policy, was forsaken by the Romans. The tribes which had most strenuously and successfully resisted the Latin invaders were cooped up in the mountain-fastnesses of Cambria and Cumbria. The tribes of prehistoric times, who had seized the island in various immigrations from different quarters, had not consolidated themselves into a national unity before Cæsar's invasion, and under the power which he introduced the spirit of rivalry, encouraged by the Roman policy—*divide et impera* (divide and overrule)—kept the several sections separate. Tribal jealousy was fanned and fostered by favours cunningly bestowed, while tribal confederation was prevented by the dexterous management of alliances and embroilments. As the power of Rome decreased, the colonists and the wealthier classes, foreseeing and fearing the possibility of invasion by the mixed populations of the opposite sea-coasts, carried their settlements inland, and fixed themselves in the most favourable places for safety and enjoyment. The municipal form of life which the Romans had introduced, now that the pressure of imperial power was removed, had resulted in these separate aggregations of populations seeking, in self-government, a secure existence. But as the Romans had sedulously kept the natives from training in arms and culture in the arts of war, the municipal corporations, though rich, were little able to protect themselves. Of course, their very wealth made them temptations, and their distinct interests led to quarrels. Their chief men sought pre-eminence. The Britons claimed their own again. Internal dissensions and external aggressions complicated the conditions of life, and in their panic-fear some of the magnates resolved to call in the help of paid troops from the Saxon shores.

Thus the British cities, whose inhabitants comprised the naturalized Roman colonists and the natives who had become semi-Romanized by interest, custom, or necessity, found themselves compelled to enter into confederacies, which were constantly changing, and to choose a chieftain, under whose command they might tide over the emergencies of the time. The employment of mercenaries, headed as they often were by daring leaders, was a policy they had soon reason to regret. These helpers soon became powerful enough to overawe the land they had been hired to protect. They saw the benefit likely to accrue to themselves by these diverse leagues and different independent states. For a considerable period the anarchy was doubtlessly great, but no record of the intrigues of the time immediately following the retirement of the Romans remains. Macaulay calls it "an age of fable," and scouts its incidents as "mythical." It seems to us, that the Anglo-Saxon and the Cambrian annals show conclusively that the intrusive population which had come from Rome, and the natives who had been subjugated by them for generations, having interests quite apart, as they must have thought, from the Celtic tribes, could not consent to their claim of sovereign rights, or concur in their appointment of a pendragon or commander-in-chief. The jealousies of right and of race gave occasion to rivalries for power. The pressure of the northern tribes into the richer lands of the south, the endeavours of the Cymry to regain their former possessions, the natural desire of the Romanic settlements to retain their previous advantages, present ample grounds for the belief that internecine wars must have been constant and weakening. When, therefore, help was sought from a vigorous people, to whom war was not only an honourable but a profitable occupation, we can easily understand how the sea-rovers of the Saxon coast—extending from the Elbe to the English Channel—on finding out the state of matters, would hasten with readiness from the opposite shore and drive their *chiules* (keels) across the intervening main, that they might secure settlements in the goodly land the Romans had left a prey to division and spoliation. For nearly two centuries the Teutonic tribes were busy in gradually making themselves masters of Britain.

A mixed multitude, in 449, made a raid upon Thanet, after having fought for the Cambrians in South Britain against the Picts, and won several battles. These came from the south of Sweden and the north of Denmark, and were called Geats or Jutes. Geoffrey of Monmouth says they came 300,000 strong, under the leadership of Hengst and Horsa—whose names, or perhaps titles rather, signify *warhorse* and *mare*. After the invaders had, at Aylesford and Crayford, defeated the Kentish Britons, they, as the Saxon Chronicle says, "took spoils innumerable, and the Wealas (strangers) fled from the Anglen like fire." In Kent and Hampshire they established themselves, and compelled Vortigern to surrender London. Merlin, it is said, brought from Ireland by magic those huge monolithic blocks of unhewn granite, blue marble, and sandstone, which form the concentric circles and the inclosed ellipses of Stonehenge, near Amesbury, on Salisbury Plain, and erected them there as a monument over 400 nobles whom Hengst had murdered at a great feast there.

The last mighty king of the British was Arthur—

> "That gray king whose name—a ghost,
> Streams, like a cloud, man-shaped, from mountain peak,
> And cleaves to cairn and cromlech still"-

so celebrated in ancient and in modern song—the typical

hero who, by his own prowess and that of the good "Knights of the Round Table," stemmed the advancing tide of Saxon aggression in twelve pitched battles—viz. one in the Glen of Northumberland, four on the Duglas, a tributary of the Ribble, and others at Bashall Brook, near Clitheroe, Celidon in Tweeddale, Castle Gwenion at Wedale, Stow, Caerleon—which some make Carlisle, and others, like Tennyson, Caerleon-on-Usk, Trath Treroit, near the Solway Frith, though others allocate it in Anglesey—Agned Cathregonion, *i.e.* Edinburgh, and Badon Hill, now Bannerdown at Bath. These are

"The several twelve pitched fields he with the Saxon fought."

The second settlement effected by the Saxons took place in 477. It was led by Ella, who, though hotly opposed, landed near Chichester, and who, after fourteen years' persistent beleaguerment, took in 491 the city Anderida (Pevensey), on the South Downs, putting the whole inhabitants to the sword. He established Sussex, the kingdom of the South Saxons.

Another band of Saxons, under Cerdic, in 495, fixed on the west as their chosen home. These ultimately became the leading tribe, and to the children of Cerdic genealogists trace the line of almost all subsequent English sovereigns. He was repulsed by Arthur at Bath, but his son, Cynric, advanced on Wiltshire, took Old Sarum; and his grandson, Ceawlin, after two victories, entailing the death of three British kings and the reduction of Cirencester, Bath, and Gloucester, carried the power of Wessex into the valley of the Severn, and won a settlement in Hereford and Worcester. Thus they succeeded in separating the Western Britons of Somerset, Devon, and Cornwall from their brethren north of the Bristol Channel.

Ercenwin laid the foundations of the East Saxon kingdom, Essex, in 526, and Uffa that of East Anglia. Other less numerous incursions took place, and their leaders reached the meeting of the three streams which form the Stour, after a stout resistance made by the landward residents to the invading settlers, who occupied Norfolk and Suffolk.

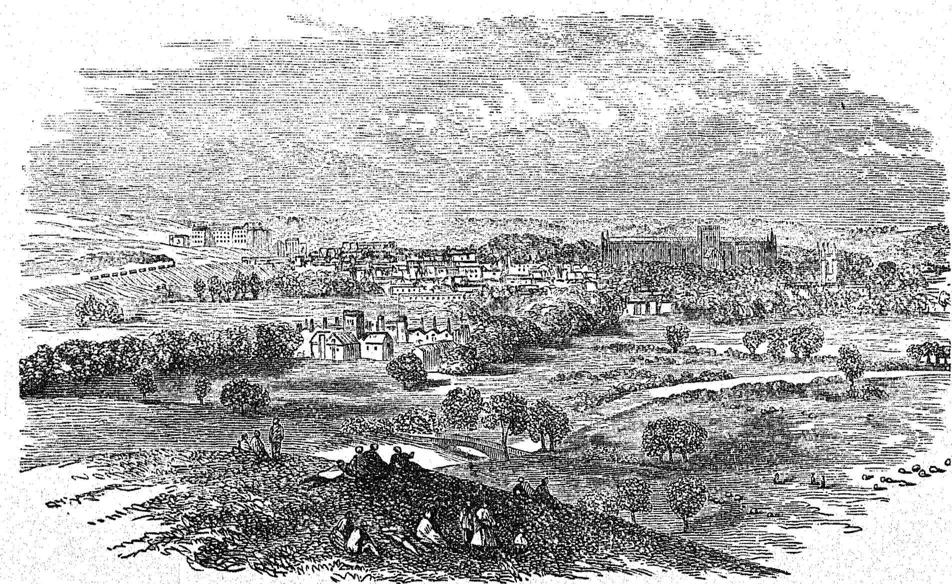
The long apprenticeship to woe of the Britons was not even then ended. Out of Angeln a large body, under the command of Ida, in 547, made an onrush to the coast near Flamborough Head, and passed thence up to the hill-country or brae-lands of Bernicia, between the Tees and the Forth, and from the North Sea to the Friths of Clyde and Solway, most of which was then comparatively wild, uncultured, and uninhabited. But at length they saw the goodness of the lands of Deira (Southland) along the frontier of the Humber and inland to the Pennine range, and made themselves possessors of both, taking the title of Northumbrians. Having gained so large an extent of land a general immigration seems to have set in from Angeln to Britain, under leaders who have not left even their names upon historic records. By constant hard fighting, all these incomers forced their way inland, and advanced by unceasing persistency "till their victorious banners," as Gibbon says, "were united in the centre of the island," forming Mercia, or the midland kingdom. The northern, central, and eastern districts of the land were held by Anglians; the southern counties, lying on both sides of the Thames, were mainly Saxon; while the Jutes possessed Kent, Hampshire, and the Isle of Wight. The Cymry were locked up in Devon and Cornwall, in the west beyond the Severn and the Dee, and in the north between the Mersey and the Clyde, and within the inclosure of the two walls. In this last retreat the Cymry were strongest. But, about 500, there came from the north of Ireland, under the chieftaincy of Fergus MacErc, the Scots, who made a descent on Caledonia, and, by their indomitable hardihood, founded, among the Romanized Britons of Strathclyde, a small kingdom. They fought stoutly against the Picts, and so saved the Saxons and Anglians trouble. Their intercourse was for a long time one of warfare only; then it became one of compromise, and at last of absorptive consolidation. The intermarriage of their royal families brought about a union of the people under one sovereign, and thereafter, as John Hill Burton remarks, "By a sort of law of attraction the term Scotia gradually loosened its hold on the old country (Ireland), and, attaching itself entirely to the new, gave it the name by which it is known in history"—Scotland. The border line between England and Scotland was, in 603, fixed by the battle of Catterick.

The full consolidation of the Anglo-Saxon tribes in England is generally assigned to the reign of the West Saxon sovereign Egbert, whose death occurred in 836. As the different tribes of Teutonic invaders pressed inland, the border territory of each tribe was pushed more and more towards the centre. Wealth and culture concentrated themselves in the midlands, for the safety that dwelt in swordsmanship was always able to be bought. The fusion of races went on most rapidly there, for the new contingents of invaders continually intensified the need for a self-protecting coalition among those whom they were gradually hemming in and crowding into city life. The cities which the Romans had walled in and fortified were eagerly sought by the rich, and the Angles, who loved the land and farm life, did not much oppose the residence of those who made the market-centres profitable. These therefore remained the chief cities in the land, and their Ealdormen were chosen their war-leaders. It was in this nominally West Saxon, but in reality chiefly Anglian, kingdom that England first consolidated itself as a national unity. This was not brought about until many changes had occurred. The Anglian settlers, who had at first spread north and west, found themselves at length compelled to seek new territory in a southern direction. They furnished lowland Scotland with her Teutonic people. Northumberland, Westmorland, Cumberland, Durham, Yorkshire, Lancashire, Cheshire, Nottingham, and some of the other midland counties, became quite Anglicized. It was a large district, where much good land was, and as the masters of York, where Rome had formerly held the seat of power, the claim to supremacy they presented was perhaps not without force. But the West Saxons who had occupied themselves in driving the Cymry into the hill-lands and colonizing the territory thus acquired, had been kept in good fighting condition, and when the smaller neighbouring nations attempted to encroach on their lands they were able to resist and subdue them. Over these they gained lordship, and among them introduced good government and able rulers. They had been able, too, to withstand the aggressions of new invaders, against whom even the Northumbrians had not been able successfully to contend. At length, after the smaller and weaker states in Britain had tried many alliances and confederacies, which were continually subject to change by their quarrellings one with another, they found that, without union, they had no chance against an ardent foreign foe. How events converged to the supremacy of Egbert, head king of the West Saxons, may here be briefly summarized.

I. *The Kingdom of Cantia or Kent.*—Kent, including the isles of Thanet and Sheppy, the earliest state fairly founded by the Saxon tribes, was also the first into which Christianity was formally introduced. Hengst's son, Esc, succeeded him in 488; Oeta and Ercenwin followed, and then Ethelbert,—after much contention and several signal defeats—acquired, on the death of Ceawlin, king of Wessex, the title and dignity of *Bretwalda* (Britain's wielder). He had married Bertha, daughter of the King of Paris, Caribert, a Christian princess, to whom the free exercise of her religion had been promised. In his reign, by command of Gregory the Great, Augustine and forty companion monks, bringing interpreters from France, came on a mission to Britain and converted the sovereign. Ethelbert forsook idolatry, sanctioned the preaching of the gospel, and assigned the monks a residence in his chief city, Canterbury. After a long and happy reign Ethelbert died in 616. His son Ealdbald succeeded him as king, but Redwald, chief lord of Anglia, was made Bretwalda. The new king was no very devout Christian, so he and his people expelled the missionaries and returned to their old Teutonic worship. Some time later Laurentius, Augustine's successor, prevailed on Ealdbald to join the sacred fold of the church, and the people, abandoning their idols, resumed their Christian profession. Eight other Escinger kings, deriving their lineage from Esc, followed and amid various fortunes held sway, but the royal line became extinct on the demise of Alric, 794. Three kings of different families, during the next thirty years, assumed dominion, but Baldred, the last of these, succumbed to Egbert, 823.

II. *South Saxons or Sussex.*—This state—founded in 490 by Ella, the first Bretwalda of the Octarchy—included Sussex and part of Surrey. It was thinly peopled, and separated by downs and marshes from communication with neighbouring states. It therefore remained a long time in its idolatrous condition. Not indeed till Wilfrid, archbishop of York, who had been exiled by Egfrid of Northumbria in 681, came and taught them some of the arts of civilization did they know of the Christian faith. Edilwalch, with his queen and many of the nobility, accepted the new doctrine, and granted Wilfrid the island of Seals (Selsey) as a site for a religious house, which was subsequently transferred to Chichester. For upwards of half a century, between the reigns of Ella and Edilwalch, Cissa, its chief, was tributary to Wessex, and after Edilwalch's defeat by Ceadwalla of Wessex, who murdered the prince's two sons, Sussex became a dependency of the western state.

III. *West Saxons or Wessex.*—This state, founded by Cerdic in 519, included Hants, Berks, Wilts, Dorset, Somerset, Devon, and part of Surrey. Cerdic and his son Cynric were succeeded by Ceawlin, who was made Bretwalda at Ella's death, and was most notable as a warlike chief. After him came Coelfric and Ceolwolf. In the reign of the next sovereign, Cynegils, Pope Honorius sent Birinus to assist in spreading the Christian faith in England. At this time Oswald of Northumbria sought the hand of Cynegils' daughter in marriage, and by his influence Birinus was welcomed from Essex and had conferred on him a grant of Dorsic in Oxfordshire, whence, 450 years afterwards, the see was removed to Lincoln. Penda, king of Mercia, drove Cenwalch, son of Cynegils and founder of Winchester minster, from the kingdom of Wessex (645). The influence of Wessex was, however, somewhat restored by Ina the Wise, famous both as warrior and legislator, who overcame Essex, built Taunton as a fortress against the Cornish Cymry, and after a thirty-seven years' reign denuded himself of power, retired with his wife to Rome, and sought by holy life to secure holy dying and eternal joy. Ina was a member of a younger branch of the Cerdic race; but after a few reigns by descendants of this cadet house, in 800, Egbert—through whom our present sovereign traces her descent from the house of Cerdic—as inheritor of the rights of the elder family, acquired the throne of Wessex.

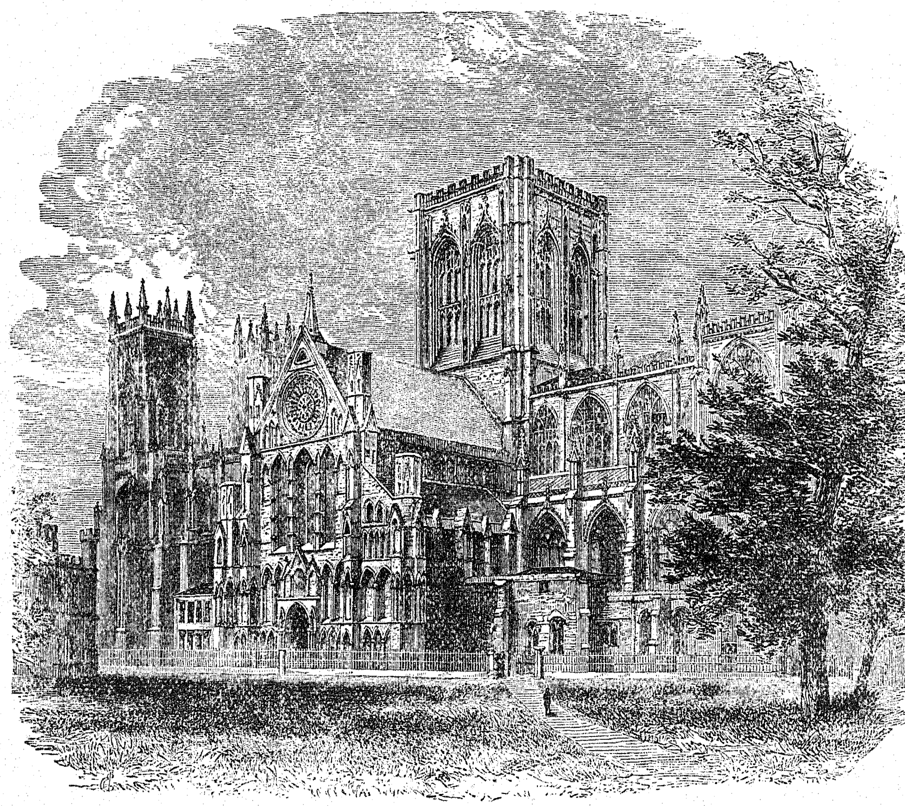


Winchester Minster.

IV. *East Saxons or Essex.*—Essex, Middlesex, and the southern part of Hertford were occupied by those Saxons whom Ercewin had led from the Saxon shore. Into it Christianity was introduced by Mellitus. To him the site of an ancient Roman temple situated on Thorney Island, dedicated to Apollo, was granted whereon to build a church. On this spot, which Sebert gave, Westminster Abbey now stands. The sons of Sebert returned to idolatry; but when in 653 Sigebert, then on a visit to Oswy of Northumbria, was called to the throne, he asked the aid of Cedd to come to Essex. Sigebert, because he was too ready to spare his enemies and forgive injuries, was murdered by two of his kinsmen. The princes who ruled this state were never very powerful. Of Ercewin's descendants the last who ruled was Selred. Three chiefs in succession tried to bear rule, but Sigired, the last of these, was compelled to yield to the victorious army of Egbert (799).

V. *Northumbria, i.e. Bernicia and Deira.*—These two provinces are the only ones which retained their ancient British name, *Bryneich* (Braelands) and *Deira* (Southland). Ida (547) founded the one, and Ella (560) the other. Edilfrid, Ida's grandson, married Aea, Ella's daughter. They, excluding Edwin, the rightful heir, from the throne of Deira, governed both kingdoms as one. Of the incident which led to Augustine's mission this is an outline:—Gregory, walking through the slave market of Rome, saw some pretty fair-haired youths exposed for sale there. "Who are these?" he asked. "*Angli*" (Angles), was the reply. "Say rather," said he, "*Angeli* (angels), which they would be if but Christians. Whence come they?" "From Deira," he was told. "That is well," he said; "they must be brought *de ira* (from the wrath) to the mercy of God." "Who is their king?" was his next question. "Ella," was the answer. "Most fittingly, then, should Alleluias be sung by such people in his land." Called to the pontificate soon thereafter, he was unable himself to engage in the conversion of England, and he committed the task to Augustine. Redwald of East Anglia, the Bretwalda, befriended Edwin, whom Edilfrid had outlawed, and on Edilfrid's death in battle, on the banks of the Idle, by his hand, restored Edwin to the throne. Edwin had married Ethelburga, daughter of Ethelbert of Kent, and she brought with her Augustine's fellow-monk, to win Northumbria to Christianity. His words were unavailing with the king, who pursued the ambitious designs of his predecessor with even greater ardour. He sent a fleet against the Cymry in Anglesey and Man, and in the north he built a new fortress-city on a hill, Edinburgh. He was created Bretwalda, and assumed all the power it gave. This incensed Cwechelm of Wessex, and he despatched Eomer to slay him. On the first day of Easter week, he, hiding a two-edged poisoned dagger under his garb, sought, as if with a message of peace, an interview with Edwin. On an opportunity occurring Eomer struck at him, but one of the king's men, throwing himself

before the monarch, loyally received the death-wound meant for him. On that day, too, Queen Ethelburga bore a daughter, Eanfled. Edwin, recognizing the double mercy of this day, vowed, if he was victor over the treacherous West Saxons, he would become a Christian. He did return triumphant, assembled his nobles, and asked Paulinus to expound the nature of the faith he taught. The tall thin form, jet hair, olive complexion, piercing eyes, Roman nose, and stately yet humble mien of the eloquent missionary of the Messiah conciliated regard, and his exposition of the mercy of God in Christ offered to sinners won their hearts. They declared against idolatry, and embraced the new faith, which spread rapidly in the north. The see of York, with its monastic school; the monastery of Yarrow (684); Hilda's Holy House at Whitby, and the bishopric of Landisfarne—subsequently transferred to Durham—were some of the early results of this conversion. Penda, the pagan chief of Mercia, slew Edwin in the field at Hatfield Chase, Yorkshire (633). Ethelburga and her daughter, under the care of Paulinus, retired to Kent. Osric, Edwin's cousin, reigned in Deira, and Eanfrith, son of Ethelfrith, in Bernicia. Oswald of the Bounteous Hand, nephew of Edwin, who had been an exile in Scotland, returned and was chosen Bretwalda. He expelled both these kings, and ruled over reunited Northumbria till slain at Maserfield (near Oswestry) by Penda the Mercian (642). Oswy, Oswald's brother, for some time shared the government with Oswin, a prince of Deira, but at length slew his copartner, attained the position of Bretwalda, and defeated Penda, with "thirty men of royal race," at Winwidfield, nea. Leeds. Egfrid, his successor, attempted the subjugation oi the Cymry of Cumberland, made war against the Mercians, from whom he took Lincoln, and was at last slain



York Minster.

in battle by the Cymry of Strathclyde, 685. Alfrith, his brother, succeeded; but civil war raged during his reign. On his death (705) Osred, his son, gained the throne, and held it till he was overcome in 716. Conred, his successor, had an easy time; so had Osric; and Ceolwulf, after a six years' reign, exchanged the monarch's crown for the priest's tonsure. Eadbert, his cousin, took his place, and twenty years afterwards followed his example by leaving the throne for the altar. Oswulf was assassinated by members of his own household. Ethelwald attained the lordship; but having slain Oswin, a noble, his subjects revolted and he resigned. Alchred was equally unsuccessful, and was expelled by Ethelred, son of Ethelwald. Alfwold next drove out Ethelred and seized the throne. This state of anarchy, which continued for a long time, invited invasion, and it came. In 794 the Northmen destroyed Landisfarne, and a warfare was commenced between the possessors and the aggressors, in which atrocities that convulsed society were committed on both sides. At length Eardwulf was driven to take refuge at the court of Charlemagne, and when, in 827, Egbert led an army against this region of rebellious men, "they offered him obedience and allegiance"

VI. *East Anglia.*—This state it is which has given name to England, *i.e.* Angle-land. The whole tribe of the Angeln migrated from their ancient home, and, leaving it uninhabited, made fresh settlements on these insular shores. They were pagans, and they drove all the dwellers in Britain (some of whom, through the Romans, had heard of Christ) into the distant districts. Eorpwald was the first prince of this invading race to embrace the gospel-faith. He, however, died early, and it was not till the reign of his step-brother, the good King Sigebert, who had been brought under Christian influence in France, that that faith was spread to any extent in Anglia. When he had made the true religion somewhat widely prevalent, he resigned the crown and went over to monastic life. The greater part of Anglian history is one of turbulence, warfare, and aggression or repression. Ethelbert, the last of its princes, was murdered by Offa of Mercia (792), and after that East Anglia was annexed to Mercia.

VII. *Mercia.*—The Anglian chief Cridda, about 586, led his followers into the woodland places, and pursuing, in a great measure, the mode of life which the forest and the chase imply, speedily overran a large tract of country. The hardy onslaughts of these rude races drove forth those who had

acquired some at least of the adjuncts of civilization during the Roman time. The old Roman settlements were abandoned. These foresters used not stone or clay, but trunks of trees, boards, rafters, &c., in the construction of their dwellings, and left the old towns to fall into ruin and forgetfulness. The early history of Mercia was made boisterous with the warlike spirit, and stained by the crimes of Penda, whose accession is dated 626. In 628 he engaged in battle with the West Saxons at Cirencester; attacked Northumbria, and slew Edwin in 633 and Oswald in 642; he drove Cenwalch of Wessex from his kingdom in 646. He was himself slain by Oswy of Northumbria, who subdued his forces and allowed his son Peada to reign as his deputy. At Medehamstead ("the home in the meadow"), Oswy and Peada (who had been converted to Christianity while on a visit to Oswy as suitor for his daughter Alchflede's hand) began, in 655, to build Peterborough Abbey. Cedd and other missionaries were also settled in Repton, Derbyshire, and made that the seat of the first Mercian see. Peada was killed at Eastertide, 657, and Wulfhere, his brother, ruled after him for eighteen years. He ravaged Wessex and the Isle of Wight. His successor, Ethelred, overran Kent. Near the Trent the Mercians and the Northumbrians had a hot engagement, which, however, terminated in a peace through the mediation of Theodore, archbishop of Canterbury. Ethelred became a monk, and Cenred succeeded him, but five years afterwards retired to Rome and died there 709. Under Coelred there was war between Mercia and Wessex again, and Ethelbald, his successor, ravaged Northumbria, and, in alliance with Wessex, attacked the Cymry; but Cuthred, the West Saxon, having quarrelled with Ethelbald, defeated him at Burford, and overcame the Cymry with his own forces. Offa, who had studied under Charlemagne, drove out Beornred, who had "obtained the kingdom and held it a little while unhappily;" made war on Kent, ravaged South Wales, defeated Cynewulf of Wessex at Bensington, and built a boundary wall between the Cymry and Mercia, running from the neighbourhood of Bristol northwards a little above Flint—called "Offa's Dyke" from that time to this. Ethelbert of East Anglia having been treacherously murdered at his court, Offa seized his dominions, but afterwards, being filled with remorse for his share in the crime, Offa resigned his crown, and died 794. Offa encouraged learning. He it was who sent to the court of Charlemagne Alcuin and his fellows—Candidus, Fredigisus, and Sigulf—to become, as it were, the inaugurators of public education in the empire of the West. In his day Cynewulf sang his sweet songs of "Elene, or the Discovery of the True Cross," and of "Juliana," the pattern of mediæval purity and the martyr of maidenliness. Offa was the founder of the first Abbey of St. Albans, and in his reign one archbishop held the see of Lichfield. He had given his daughter Eadburg in marriage to Brithric, king of Wessex. He died, poisoned by his wife, in 800, and Egbert was chosen to succeed him.

This Egbert, the fourth in direct descent from Ingils, the brother of Ina the Wise, had been banished by Brithric and taken refuge in the court of Charlemagne, among whose followers he was when the dignity of Emperor of the West was conferred on him at Rome. On being recalled to Wessex he made war against the Cymry, and while the other sovereignties were weakened by internecine slaughter he strengthened his power. Knowing the real condition of the adjoining states, he projected a scheme of conquest, which in 810 he began, and in eighteen years succeeded in making himself sole monarch of the land, parcelling out the government among tributary kings.

By hereditary right, marriage, or conquest Egbert acquired such supremacy that the dignity of Bretwalda was revived for him in 827, and in 828 he designates himself in a charter "King of the English." He was the most astute politician and the bravest warrior of his age. By the sword which had served Charlemagne he subdued Devon and Cornwall, deposed Ceolwulf, defeated his successor Beornwulf (825) on that terrible field of fight, near Wilton, of which the Chronicle relates that

"Ellandune stream was choked with slain and foully stained with gore."

He overcame Kent, brought the men of Surrey, Sussex, and Essex under his sway, made war successfully on the Cymry of the wild western trans-Severn regions, and encountered with undaunted courage the terrible Northmen, who, however, defeated him in 833 at Charmouth, Dorset. When the Danes, in 835, in alliance with the Cymry of Devon and Cornwall, came in great hosts to invade the southern shores of Britain, he repulsed them frequently, and in a great battle at Hengesdown, in Cornwall, inflicted on them a severe defeat. In the following year he died, ripe in years and full of honours.

Ethelwulf, eldest (surviving) son of Egbert, a pious, mild-minded man, who had been in early life destined for the church, and was rather ill-suited for a king, inherited his place and power. He assigned the administration of the south and east of his dominions to his brother Athelstan. Ethelwulf had married Osburga, daughter of Oslac, a descendant of Cerdic. He had by her four sons and two daughters. To his youngest son, Alfred, he designed to leave his throne, and to be prepared for his position Alfred was sent to Rome when five years of age. Ethelwulf's reign is chiefly remarkable for the sufferings endured from the annual incursions of the Danes. They had harried the Saxon shore on the Continent, but being repulsed there, turned their ships' prows to the insular coasts. Now they swept up the narrow river courses of the south-west—again they landed at Sandwich; one year they settled on Thanet and Sheppy—another they passed up the Thames and plundered Canterbury. The country was roused. In 851 they came more numerously than ever. Ethelwulf and his eldest son Ethelbald went to Athelstan's aid, and at Ockley inflicted on their heathen invaders the most terrible slaughter that had been up till that time noted in Anglo-Saxon records, when

"Men fell like corn in harvest-time in both these mighty hosts."

The Vikings were, however, under too heavy a pressure from necessity to seek settlements somewhere. Again and again they returned and were resisted. At length, though they had made good their footing for a winter in Sheppy, they were again defeated, and Ethelwulf in his joy assigned by charter to the church one-tenth of his own lands throughout the realm, "for the glory of God and his own eternal weal," and made a pilgrimage to Rome. He remained there a year. On his way home Ethelwulf was the guest of Charles the Bald, and being now a widower, he married Judith the daughter of the King of the Franks, then only twelve years of age. The people were greatly enraged at this marriage, and when his sons learned that the Pope had made Alfred his godson and anointed him as a king, they led a revolt against their father. He purchased peace by conferring the sovereignty of Wessex upon Ethelbald, and arranging that the succession should proceed in the natural order. In 858 he died, and was buried in Winchester.

Ethelbald, who invited his brother Ethelbert to share the sovereignty with him, hastily married his step-mother Judith against the advice of the celebrated St. Swithin. The Danish incursions still continued, but they were carefully watched and bravely repulsed. Ethelbald died in 858. Judith, who had no issue by either union, returned to her father's court, married again, and became the ancestress of the Dukes of Flanders. Ethelbert then succeeded to all the realm of his brother. The Danes renewed their incursions with fiercer activity than ever; he struggled manfully to overmaster them. They broke into Winchester, and plundered Kent. The three sons of Ragnar Lodbrog, a Norse Viking who had been wrecked on the Northumbrian coast and put to death with coarse cruelty there, had resolved to avenge their father's fate. They had ravaged the north, and fixed a colony there; overrun Mercia, and made themselves masters of many of the chief towns in the Trent Valley; invaded the Fen-land, pillaged the people, burned down the churches; and had set up a new kingdom in East Anglia. Now they came breathing out threatenings and slaughter in Wessex. Just when all the valour of a well-established regal power was required to cope with the Scandinavian thirst for vengeance, need of settlements, and greed of power, the Saxon states were weakened by the death of Ethelbert.

Ethelred was crowned king, and Alfred his brother, back

from Rome, was named his *Secondarius*—a sort of regal prime minister, governor, or regent, who could act for the king in his absence. The unsettled condition of the country had interfered with the progress of husbandry, and a famine arose, followed by a pestilence. The enemy was alert on every coast, and difficulty beset the English on every hand. Ubba and Halfdan, with Ingwar the Boneless, came, meaning to gain and retain lordship over the land. Nine battles were fought with varying success. Northumbria was in the power of the invaders; Mercia was weak and wavering; Guthrum the Dane was supreme in East Anglia, for Edmund the under-king had been taken prisoner and asked to recant his Christian faith. On his refusal he was cruelly scourged, fastened to a tree, made a target for the arrows of whosoever listed of the foe, and had his head struck off. The martyr-king was laid to rest in Bury St. Edmunds (870). The adverse host, after a defeat at Englefield, came to Reading, in Wessex, in 871. Between the Thames and the Kennet they drew up. They withstood and slew the ealdormen Sidroc and Ethelwulf. Ethelred and Alfred came up to them at Ashdown four days thereafter, and Asser relates, on the authority of eye-witnesses, that while the former was hearing mass the latter rushed on alone, like a wild boar at bay, and the banner of the White Horse triumphed over the standard of the Black Raven on a blood-red ground, on which the daughters of Ragnar Lodbrog had, by magic aid, wrought the device *Landeyda* ("the desolation of the country"). Rapidly reinforced they fought again at Basing, and were not repelled. Two months more elapsed, and they met again at Merton. Here the Danes held possession of the field of carnage. Here, too, Ethelred, who had been fatally wounded, died in Eastertide, and was buried in Wimborne. Ethelred left two infant children, but in these days lineal succession was not fixed, and Alfred, who had been anointed king by Leo IV., assumed the government of the whole realm, "with the greatest good-will of all the inhabitants of the kingdom."

Alfred the Great was twenty-two when he began to reign. His wife, Elswitha, was the daughter of an ealdorman of Lincoln, whose mother belonged to the royal house of Mercia. His sister had, eighteen years previously, married Burgred, king of Mercia, who helped him in his warfare with the invading enemy. Against them, in the first year of his reign, Alfred fought nine battles. He was fain to purchase peace from them, and they wintered in London. Before them, his Mercian brother-in-law was driven from his throne and fled to Rome, while his wife found asylum with Alfred. He equipped a fleet of 120 vessels, and endeavoured to defeat the foe on the sea, and in 875 succeeded for once. During seven years, inroads, opposed by desultory efforts, were made by the Northmen—truces, hostages, oaths of allegiance, and payments of money were as vain as battle to ward off the danger. Just after Twelfth Night, 878, the Danes surprised him at Chippenham, drove many people beyond the sea, and enforced submission. Alfred, with a small band, retreated with difficulty to the woods and to the fastnesses of the moorlands of Somerset. On a small river-islet, between the Tone and the Parret—since called Athelney ("the Isle of the Nobles")—he found safety and rest. Here, during seven weeks, he underwent many singular trials and adventures. Then he defeated Ubba, in Devonshire, and took "the Raven." After a stubborn fight at Ethandune, from which the Danes fled, Alfred besieged the foe so successfully at Chippenham that they were compelled to make peace with him—swearing to become Christians or to leave the land for ever. Many departed and carried their arms to Rollo in Normandy. To others, Alfred ceded an extensive tract of land north and east of Watling Street, afterwards called the Danelagh, and gave them an opportunity of entering into the national brotherhood as settlers, over whom were common laws, by whom a common faith was held. In the earlier years of his reign Alfred was arbitrary and frequently to blame, but trouble increased his wisdom and heightened his piety. He sought to have his king's work well done. He aimed at having the land systematically tilled by the people who occupied it, and to have in ample sufficiency in it "prayer-men, army-men, and working-men." The great arts of life were fostered, intelligence was cultured, and, through trade and the church, Britain was kept in connection with the commonwealth of continental communities. He founded the British navy, organized a militia, instituted trial by jury, and enforced the co-responsibility of residents by requiring bail to be found among neighbours for those charged with crime. He patronized learning, compiled laws, had a survey of England made, and carried on many public works. Though knowing from an early age that he suffered from a painful incurable disease, he fought personally in fifty-six battles, and was noted both for literary skill and statesmanly ability. When, in 893, the Danes returned under Hastings from continental marauding, he successfully resisted them at Farnham, Benfleet, and the Isle of Wight, and, through a five years' conflict, maintained his ground so well that they gave up all hope of winning the island, and went elsewhere to seek booty. The princes of the Cymry came of their own will to ask him to protect them from the Danes and be their overlord. Britain, south of the Humber, was willingly subject to his sway, and when on the 26th October, 901, he died peacefully, all England mourned the loss of "Alfred the truth-teller, England's darling." Among the children of historic note whom Alfred left, there were Ethelfleda, the Lady of Mercia; Elfrida, married to Baldwin II., duke of Flanders, son of Judith, Alfred's step-mother, and ancestor of the first Norman queen of England—Matilda; Ethelgina, abbess of Shaftesbury; and Edward, his successor.

Edward (named the Elder, to distinguish him from Edward the Martyr, Edward the Confessor, Edward the Outlaw, &c.), though elected by the Witenagemote, was opposed by his cousin Ethelwald, son of Alfred's elder brother. A civil war ensued, and Ethelwald appealed to the Danes of the Danelagh to aid him. Edward, however, several times defeated them. In one of the skirmishes, Ethelwald was slain. For seven years, Edward and his sister Ethelfleda were engaged in building a chain of forts from Bedford to Runcorn. Ethelfleda took the Queen of the Cymry captive at Brecknock, and Edward, driving the great host of the Danes from his shores, made them seek refuge in Ireland. Having put down all his opponents, the Danish chiefs, Constantine of Scotland, Llewellyn of Wales, and the chiefs of the Britons of Strathclyde acknowledged his overlordship. Ethelfleda having died at Tamworth, 922, Mercia accepted him as king. In 925 Edward also died and was interred at Winchester, an unconquered king, leaving to his son Athelstan the dominion of all Britain "within the four seas."

Athelstan, Alfred's favourite and Ethelfleda's pupil, a slim, fair-haired, handsome young man, was crowned at Kingston. At Eamote he received, as homagers, the Scottish, Danish, and Cymric kings. The Scottish monarch was Constantine III., son of Aodh or Hugh, who had resisted the Danes when they made their incursions from Ireland; the Cymric kings were Howel Dha of West Wales, and Owain of Gwent; while the representative of the Northumbrian Danes was Ealdred of Bamborough. It is probable, however, that this was a mutual interchange of greetings intended as preliminary to an amicable league for mutual protection—rather a friendly commendation of themselves to their newly-elevated neighbour than any real confederacy of the kings offering vassal homage to a feudal superior.

A conspiracy by one of his nobles, Elfred, to depose him and put out his eyes was discovered. This he defeated. He had bestowed on Sihtric, the Danish chief of Northumbria, the hand of his sister Edgitha in marriage. Sihtric renounced his Christian faith and dismissed his wife. Athelstan set out to avenge both crimes, but before he arrived Sihtric was dead, and his sons, Anlaf and Guthferth, had fled to Scotland. The former of these married the daughter of Constantine III. Athelstan assumed the overlordship of Northumbria, then he took the title of "King of all England," and held sway almost undisturbed for nearly ten years.

Constantine III. of Scotland, resolving to throw off allegiance to Athelstan, called Anlaf o' the Sandal, his son-in-law, to his aid, and invited the Irish and the Britons of Cumbria to join him. They gathered their forces together, a mighty mass of men, and Anlaf brought, in 615 ships, another host by sea. Athelstan and Edmund his brother advanced against the allied invaders. They met on the fatal field of Brunanburgh—some say near Ford, in Northumberland—

in 937, and a signal overthrow of the confederates was the result. The Saxon Chronicle burgeons into rapid rushing song in narrating it. We quote a few lines:—

"Low lay their Scottish foes, and death-doomed fell
The shipmen. . . . . There lay five kings,
Whom on the battlefield swords sent to sleep,
And they were young; and seven of Anlaf's earls,
With Scots and mariners, an untold host. . . .
Put to flight there was the Lord of the Northmen,
Driven by need to the bow of his bark.
. . . . Slaughter more than this
Was in this island never yet."

Athelstan laid the Cymry under tribute, colonized Exeter as a trading-port, with English, and confined the Cymry to Cornwall. He was famous abroad. Many foreign sovereigns sought his friendship. He aided Haco, one of the first kings of Norway to introduce Christianity, to win his crown. Under him Saxon England reached its supremest height of renown. His integrity and wisdom, piety, and power not only enabled him to consolidate the nation by prudent policy and excellent administration, but also to exert great influence in the affairs of neighbouring states. Indeed for some years prior to his death he may be said to have held in his hands "the balance of power in Europe." He died at Gloucester, 25th October, 941, unmarried, aged 47, and was buried under the altar of Malmesbury Abbey. His life was, as William of Malmesbury has said, "Little in time, in action great." In compacting the kingdom into a unity, and in aiming at welding all the dwellers in the island into oneness of constitutional power, although held by different subkings officially, he succeeded singularly well without pushing the desire for personal aggrandizement so far as to be obnoxious or irritating. Under Athelstan, while civilization and improvement went on within the realm, the consequence and influence of England among the powers of Europe were well established. He was himself studious and religious, under the sway of high principle, and anxious that, through the translation of the gospel into the vernacular and the persuasive power of the church, nobles and people might be brought to dwell in concord and mutual helpfulness. The merits of Alfred as a monarch, and the excellencies of Edward as a statesman, were realized in union in Athelstan, the son of Eawine, the humble shepherd's daughter, whom Edward made his consort, and by whose teaching the prince was prepared to plan and provide for the protection of the poor, the promotion of commerce, the security of industry, the exercise of mercy, and the real power of religion, and so to become a veritable sovereign, mighty—and acknowledged as such—in

"This boisterous world of sceptres and of swords."

THE GREEK LANGUAGE.—CHAPTER II.

SECOND DECLENSION.

THE Second Declension has two terminations, ος and ον. Nouns in ος are masculine (sometimes feminine); nouns in ον are always neuter, except in some diminutives of female proper names; as Γλυκεριον, from Γλυκερα.

NOUNS OF THE SECOND DECLENSION.

	Masculine.	*Feminine.*	*Neuter.*	*Masculine.*	*Neuter.*
Singular.	a man.	the way.	a rose.	the mind.	the bone.
Nom., ...	ἀνθρωπος	ὁδος	ῥοδον	νοος νους	ὀστεον ὀστουν
Gen., ...	ἀνθρωπου	ὁδου	ῥοδου	νοου νου	ὀστεου ὀστου
Dat	ἀνθρωπῳ	ὁδῳ	ῥοδῳ	νοῳ νῳ	ὀστεῳ ὀστῳ
Acc., ...	ἀνθρωπον	ὁδον	ῥοδον	νοον νουν	ὀστεον ὀστουν
Voc., ...	ἀνθρωπε	ὁδε	ῥοδον	νοε νου	ὀστεον ὀστουν
Dual.					
Nom. Acc. Voc., . .	ἀνθρωπω	ὁδω	ῥοδω	νοω νω	ὀστεω ὀστω
Gen. Dat., ...	ἀνθρωποιν	ὁδοιν	ῥοδοιν	νοοιν νοιν	ὀστεοιν ὀστοιν
Plural.					
Nom. Voc., ...	ἀνθρωποι	ὁδοι	ῥοδα	νοοι νοι	ὀστεα ὀστα
Gen., ...	ἀνθρωπων	ὁδων	ῥοδων	νοων νων	ὀστεων ὀστων
Dat., ...	ἀνθρωποις	ὁδοις	ῥοδοις	νοοις νοις	ὀστεοις ὀστοις
Acc.	ἀνθρωπους	ὁδους	ῥοδα	νοους νους	ὀστεα ὀστα

νοος and ὀστεον are contracted to νους and ὀστουν; we give both forms of declension above.

Decline similarly—ἀγγελος, a messenger; ἀγρος, a field; στεφανος, a crown; παρθενος, a virgin; φηγος, a beech; παιδιον, a child; φαρμακον, a drug; μετρον, a measure; μηλον, an apple; ἐργον, a work; ἱματιον, a garment.

In contracted nouns of the second declension—

(1) The letters εο, οε, and οο become ου; as ἀδελφιδεος, contracted ἀδελφιδους; νοε, νου; νοος, νους.

(2) A short vowel before a long one or a diphthong is absorbed; as πλοων, πλων; πλοοιν, πλοιν.

(3) In the neuter α absorbs the preceding vowel, and becomes long; as ὀστεα, ὀστᾶ.

(4) In the vocative εε is not contracted; as ἀδελφιδεε.

Some nouns alter the gender, and with it the meaning; as ὁ ζυγος, the yoke, ἡ ζυγος, the balance; ὁ ἱππος, the horse, ἡ ἱππος, the cavalry, and also the mare; ὁ λεκιθος, pulse-broth, ἡ λεκιθος, the yolk of an egg.

The following have the neuter form in the plural:—

ὁ βοστρυχος,	τα βοστρυχα.	the curl.
ὁ δεσμος,	τα δεσμα.	the chain.
ὁ θεσμος,	τα θεσμα,	the law.
ὁ διφρος,	τα διφρα.	the chariot-seat.
ἡ κελευθος,	τα κελευθα,	the way.
ὁ λυχνος,	τα λυχνα,	the torch.
ὁ σιτος,	τα σιτα	the corn.

Θεος, God (like *Deus* in Latin) has the vocative the same as the nominative; so also often, but not always, φιλος, a friend.

What is usually called the Attic Declension is only the Second Declension with those peculiarities which arise from the contraction of the vowels α and ο, as shown in page 192. It contains but a few words and parts of words, and has two terminations, ως and ων; ως is masculine or feminine, ων neuter.

Singular.	a hare.	an upper chamber.
Nom. Voc., ...	λαγως	ἀνωγεων
Gen., ...	λαγω	ἀνωγεω
Dat., ...	λαγῳ	ἀνωγεῳ
Acc., ...	λαγων (or λαγω)	ἀνωγεων
Dual.		
Nom. Acc. Voc., .	λαγω	ἀνωγεω
Gen. Dat., . . .	λαγῳν	ἀνωγεῳν
Plural.		
Nom. Voc., . . .	λαγῳ	ἀνωγεῳ
Gen., ...	λαγων	ἀνωγεων
Dat., ...	λαγῳς	ἀνωγεῳ.
Acc., ...	λαγως	ἀνωγεω

The following words are to be declined in the same manner:—νεως, *m.*, a temple; ταως, *m.*, a peacock; αλως, *f.*, a threshing-floor; ευγεων, *n.*, fertile; ἵλεων, *n.*, propitious;

βαθυγεων, *n.*, deep. Ἑως, dawn, and names of places, Ἀ ως, Τεως, &c., take accusative ω.

Only one neuter in ως is assigned to this form of declension; viz. χρεως, the debt. According to the ancient grammarians, it has χρεως not only in the accusative, but also in the genitive singular. All the other parts are formed from χρεος; thus, plural χρεα, &c.

A considerable number of proper names take this form, as Βριαρεως, Briareus; and some adjectives, as ἱλεως, favourable. Some vary into the third declension, as καλως, sail-rope.

Wherever in the ordinary declension there is an iota (ι) in the inflexion, an iota is subscript in the Attic form.

Decline the following nouns, writing them out carefully through all their cases and numbers, and attending to their gender:—

ἀετος, *m.*	eagle.	κασσιτερος, *m.*	tin.
ἀμπελος, *f.*	the vine.	κοτινος *m.*	wild-olive tree.
ἀργυρος, *m.* / ἀργυριον, *n.*	silver.	μολιβδος, *m.*	lead.
		νοτος, *m.*	south-wind.
ευρος, *m.*	east-wind.	ξυλον, *n.*	wood.
ζεφυρος, *m.*	west-wind.	σιδηρος, *m.*	iron.
ἰον, *n.*	violet.	στρατος, *m.*	army.

THIRD DECLENSION.

Nouns of the Third Declension have the following endings:—α, ι, υ, ω, ν, ρ, ς (ξ, ψ), including γυνη (originally γυναιξ), a woman. These increase by one syllable in the oblique cases, as will be seen in the following table:—

Nouns of the Third Declension.

	Masculine.	*Masc.* or *Fem.*	*Masculine.*	*Masculine.*	*Masculine.*	*Neuter.*	*Masculine.*	*Feminine.*
Singular.	a Greek.	a child.	a beast.	a raven.	a lion.	an affair.	an elephant.	a helmet
Nom., . . .	Ἑλλην	παις	θηρ	κοραξ	λεων	πραγμα	ἐλεφας	κορυς
Gen., . . .	Ἑλληνος	παιδος	θηρος	κορακος	λεοντος	πραγματος	ἐλεφαντος	κορυθος
Dat., . . .	Ἑλληνι	παιδι	θηρι	κορακι	λεοντι	πραγματι	ἐλεφαντι	κορυθι
Acc., . . .	Ἑλληνα	παιδα	θηρα	κορακα	λεοντα	πραγμα	ἐλεφαντα	κορυθα and υν
Voc., . . .	Ἑλλην	παι	θηρ	κοραξ	λεον	πραγμα	ἐλεφας	κορυς
Dual.								
Nom. Acc. Voc.	Ἑλληνε	παιδε	θηρε	κορακε	λεοντε	πραγματε	ἐλεφαντε	κορυθε
Gen. Dat., .	Ἑλληνοιν	παιδοιν	θηροιν	κορακοιν	λεοντοιν	πραγματοιν	ἐλεφαντοιν	κορυθοιν
Plural.								
Nom. Voc., .	Ἑλληνες	παιδες	θηρες	κορακες	λεοντες	πραγματαν	ἐλεφαντες	κορυθες
Gen., . . .	Ελληνων	παιδων	θηρων	κορακων	λεοντων	πραγματω	ἐλεφαντων	κορυθων
Dat., . . .	Ἑλλησι	παισι	θηρσι	κοραξι	λεουσι	πραγμασι	ἐλεφασι	κορυσι
Acc., . . .	Ἑλληνας	παιδας	θηρας	κορακας	λεοντας	πραγματα	ἐλεφαντας	κορυθας

Decline similarly –

ἐλπις, ιδος, *f.*	hope.	γιγας, αντος, *m.*	a giant.
σωτηρ, ρος, *m.*	a preserver.	ἀξιωμα, ατος, *n.*	value, dignity
χειμων, ωνος, *m.*	a storm, winter.	χειρ, χειρος, *f.*	the hand.
θερος, εος, *n.*	summer.	ἐσθης, ητος, *f.*	clothing.
πατηρ, ερος, *m.*	a father.	ὑποδεσις, εως, *f.*	a sandal.
ἡγεμων, ονος, *m.*	a leader.	σωμα, ματος, *m.*	the body.
τειχος, εος, *n.*	a wall.	μελι, λιτος, *m.*	honey.
μαντις, εως, *m.*	a seer, prophet.	γονυ, ατος, *m.*	the knee.
οἰκησις, εως, *f.*	habitation.	μην, μηνος, *m.*	a month.
ἐρις, ιδος, *f.*	contention.	ποιμην, ενος, *m.*	a shepherd.

The nominative of a noun being known, the student can easily find out in a lexicon or dictionary both its signification and its declension. But if he cannot, from its being in an oblique case, ascertain the nominative, he will not know how to consult his dictionary with advantage. In the First and Second Declension there is little trouble, but in the Third it is not an easy matter always to discover the precise nominative.

The *roots* of nouns of the Third Declension end in one or other of these three ways—(1) In one of the nine mutes: (*a*) soft, π, κ, τ; (*b*) intermediate, β, γ, δ; (*c*) aspirate, φ, χ, θ; (2) in one of these three liquids, λ, ν, ρ; or (3) in one of the vowels ε, α ι ο, υ, doubtful. But some mutes end in a liquid and a mute together; as ρκ, ντ, γγ (*i.e.* νγ), and κτ; as σαρξ, σαρκος, flesh; γιγας, γιγαντος, giant; σαλπιγξ, σαλπιγγος, trumpet; ἀναξ, ανακτος, sovereign. In regard to mutes, the Greeks were offended by the concurrence of ς with dentals, τ, δ, θ, and hence they deleted these in the nominative; as τερας, τερα(το)ς, a sign; λαμπας, λαμπα(δο)ς, a lamp; ορνις, ορνι(δο)ς, a bird. In some nouns delicacy of sound was preserved by deleting τς and lengthening the penultimate ο; as in δρακων, δρακον(τος), a dragon. These letters τς were also deleted after ι; as μελι(τος), honey. Of liquids, μ is never found at the end of a root, and λ is only found in ἁλς, salt, the sea; ν and ρ are final in the root. In general, especially in masculine and feminine nouns, a short vowel preceding the terminal inflexion becomes long in the nominative, or is converted into a diphthong; as οδους, οδοντος, a tooth. It will be seen from the foregoing statements that the nominative of this declension seldom contains the unaltered root. It may be got, in general, from the genitive by throwing off ος.

To find the nominative from an oblique case, if the root ends in a consonant—

(1) Add ς to the nominative; (2) throw away the *t* sounds and ν before this ς; (3) if ντ has been thrown away, the vowel must be lengthened: ε, ο become ει, ου, *i.e.* αντς, εντς, οντς, υντς become ᾶς, εις, ους, ῦς; (4) ε, ο in masculine and feminine nouns pass into η, ω, unless the nominative ends in ξ or ψ; (5) from roots in οντ, sometimes the τ falls off, and the nominative is ων, hence roots that end in οντ belong to nominative ους or ων; (6) roots in ατ sometimes belong to nominative α (neuter) or αρ, ωρ; (7) roots ending in ν or ρ are often without the ς in the nominative: but here too ε, ο become η, ω.

DEFECTIVE NOUNS.

(1) The following want the genitive and dative:—δεμας, the body; σελας, a beam of light; λεπας, a rugged rock; ἡδος, sweetness; ὀφελος, advantage; βρετας, a shrine; ὀναρ, a dream; σεβας, worship; οὐδας, the ground.

(2) Names of festivals, and a few of cities, want the singular; as Διονυσια, the festival of Bacchus; Μεγαρα, Megara.

(3) Several want the dual, and generally the plural number; as ἀηρ, the air (though Plato has ἀερως, Phæd. 108); ἁλος, feminine (the nominative not used), of the sea; in the plural masculine, ἁλες, salt (Aristoph. Acharn. 760); γη, the earth; πυρ, fire (the plural is sometimes used of the Second Declension; ἐλαιον, oil; αἰδως, modesty; and almost all abstract nouns.

PATRONYMICS.

Masculine patronymics end in δης or ων, and are formed from the dative singular of proper names; as Νεστωρ, Νεστορι, Νεστοριδης, a son of Nestor; Ἀτρευς, Ἀτρει, Ἀτρειδης, a son of Atreus; Πηλευς, Πηλει, Πηλειδης, Achilles. Patronymics formed from nouns of the Second Declension subjoin δης and ων to the old form of the dative, by omitting the prepositive vowel; thus, Κρονος, Saturn, Κρονοι, Κρονι, Κρονιδης and Κρονιων, a son of Saturn.

GENDER OF NOUNS.

Sex often determines the gender of nouns. Islands, cities, trees, plants, and flowers are generally feminine. In the Third Declension, nouns ending in ευς, ων, and αν are masculine; those in ας, της, αυς, and ω are feminine; and those in α, ι, υ, ας, and ος are neuter.

ATHLETIC SPORTS AND PASTIMES,

A SYSTEM OF

PHYSICAL EDUCATION.

INTRODUCTORY.

THE complete and harmonious development of man's whole nature is education. In the highest and best sense education may be regarded as the safeguard of health and the condition of happiness. Rational self-culture is not the mere acquisition of information, however extensive and interesting, but of knowledge organised into science and capable of use in the varied duties and pursuits of life. "Knowledge *is* power;" but energy is work-power; and success in life depends on knowledge energised and utilised. Intellectual training must be combined with true vigour of *physique* if a man is to be brought up to his best. Genuine self-culture implies health of body and of mind—unstinted knowledge and unstunted growth. This is only attainable by a wise and resolute expenditure of energy, time, and means. Strong will, seconded by abundant physical vigour, are indispensable factors in an education which includes living, knowing, and doing, and looks after the forming of the body, the informing of the mind, the performing of a fair share of the world's work, and the getting of a due proportion of pleasure while doing it. When intellectual and physical education are duly co-ordinated, knowledge will be vital, skill real, and life practical; man will be robust in body, goodly in growth, wholesome in tastes, keen in sensibility, large of heart, strong in brain, pure in habit, rich in thought, loyal in friendship, upright in business, zealous in patriotism, mirthful in leisure, kindly in spirit, and obedient to all Divine and right civil laws.

Physical exercise is the act of setting and keeping the mechanism of the body in operation voluntarily and with a view of enjoying the pleasure it yields and of benefiting from the good results to which it tends. We take food to enable us to work; it supplies the means of doing, and is the physical source of bodily strength. The knowledge of the changes which take place in the human organism will help us to understand the true use of food as the staple source of the power to work, which we call energy. Work is the production of some intentional change in the state or relations of things in opposition to some force which resists change. Thus the muscular power of the arm is used to change the conditions of the elasticity of a bow from its normal quiescent state to one of resilience or readiness to spring back; the blacksmith lifts and wields his fore-hammer by muscular force in opposition to the resistance of weight or gravity. We may, indeed, replace power of muscle by steam, electricity, &c., and cause these energies to work for us. This shows that force is the ability to produce change. It may be either potential or active, but it is indestructible. In the bones of the skeleton and the ligaments, tendons, &c., which unite them, our potential power of movement exists; and in the muscles, nerves, &c., our active causative power of motion resides. Changes in the nerves cause contraction in the muscles; their contraction brings the bones nearer to one another, and their expansion enables them to renew their

position. Thus work is effected by changing and changeable force. Firm, healthy, living muscle is the power by which work is done. This working energy is produced by chemical changes in the muscular material, and the chemical components of these changes are derived from food suitable to the frame and thoroughly assimilated by it. To make good the double loss of matter and of energy expended in work, these chemical elements must not only be supplied to but be inwrought with the muscles, and hence exercise is necessary to renew and invigorate the bodily structures and replenish them with vital energy.

Physical education promotes a graceful and gracious self-possession. It imparts a sense of ease and readiness, a capacity for prudent promptitude, and the power of patient perseverance and endurance when need arises. The man who has gained a pretty tolerable control over the whole mechanical apparatus of his body is little disposed to be flurried or awkward when circumstances require danger to be faced or courage displayed. Danger is never decreased, but often increased, by unnecessary fears, or a feeling of unpreparedness. Any apprehension in regard to comporting oneself well in new surroundings or unexpected situations disturbs a disciplined man much less than one who has not been trained to self-management. The former has got accustomed to speedy and effective action; the latter can with difficulty avoid confusion and hesitancy when difficulties present themselves. Inexperience trembles at trifles, experience gained in self-management quickens one up to some degree of resolution to attempt to overcome what seems to be threatening. The habit of self-reliance comes to one's help, and almost instinctively our resources are utilized, and we are ready to encounter even the unwonted valiantly. Obviously, physical education, by fitting the several members of the body for the easy, natural, and economical performance of all their functions, provides the pupil with the power of bringing to bear, at once, the requisite action of the human machine for the accomplishment of any needed task or duty —muscle, sinew, and nerve, bone and joint, each being trained to prompt and harmonized action in obedience to the will.

Under differing names—gymnastics, drill, athletic sports &c.—we have various manuals of the art of enhancing bodily strength, and training its activities to agility in personal accomplishments, and in competitive or combined encounters of might and speed. Much of the teaching given under these names has hitherto been empirical—founded on experience rather than on principles, and having the exhibition of personal prowess, the attainment of professional glory, or the securing of public rewards or praise for their ends. Around them have accumulated many traditional rules and many extraneous attractions. They each, more or less, have display and public success in view. Our desire is to enfranchise them from these subtly engrossing accidents, and to bring them under the consideration of our readers as ordinary elements in educational training and truly recreative influences in individual and social existence. This will give a specialty to our expositions and instructions, and necessitate a novelty of outlook and of presentation to our method. Our chief effort will be to supply a knowledge of principles, and to apply these to the improvement of the self-educator in person and deportment, and through him to the promotion of the general advancement of the community.

The aim of these chapters on physical education is not to induce young men to undertake special training that they may become athletes and professionalists in games and sports. Our design in them is rather to commend the culture of the body in such a way as shall keep it natural, healthy, and strong, well poised in every part, working in well-adjusted copartnery of effort in all that tends to make a useful, capable, and active frame, properly fitted to perform every physical duty easily and pleasantly. Strong arms, fleet feet, supple joints, brawny muscles, lusty lungs, unwavering heart, sound stomach, healthy skin, vigorous brain, and an easy yet graceful carriage may be gained, in large measure, by any one having originally an average constitution who devotes due attention daily to the laws of health and the taking of moderate, well-regulated exercise pursued in a systematic manner for the development of all the faculties of the frame. Health is really definable as the possession of a general and uniformly diffused strength in all the organs and functions of the body, that vital capacity which enables one in his own place and condition to pursue his calling in life with the greatest comfort and highest usefulness. Wherever health is, there are stamina, endurance, tone, relish for and zest in work, love of the exercise of our powers. But if exercise is not duly taken, appetite fails, refreshing sleep is not obtained, and restorative nutrition is impossible. Unfortunately those who are most in need of exercise are least disposed to take it, though it is the one indispensable medicament for the languidness and *malaise* of ill health.

We have in the foregoing part of this work provided some aid to intellectual, artistic, scientific, literary, and historical culture. We think that we may, perhaps, have erred in endeavouring to supply the means of self-culture for the mind, and in neglecting to furnish an equally careful outline of such training as makes and keeps the body healthy and secures to it, as far as possible, usefulness, pliancy, elegance, and comfort. In seeking to realize all that is best in man as man, bodily discipline is not less essential than mental enlightenment. It is possible by sagacious guidance and instruction to increase and quicken skill in nerve and muscle, improve the acuteness and serviceability of the senses, and impart to the physical frame expertness and dexterity. To accustom the body to the use of the best and easiest methods of activity, and to induce habits which fit man to perform his duty well in all that concerns social existence, is to give a good outfit not only for making a fair start in life, but of leading to patient continuance in well-doing throughout it. We intend therefore, in the following chapters on educative and recreative exercises, to aid, as well as we can, the self-instructor in the attainment of physical health, activity, usefulness, and enjoyment.

It cannot be doubted that to bring energy and spirit habitually into exercise in the ordinary work of life is beneficial to a person, advantageous to the community in which he resides, and pleasant to the social circle of which he is a member, as well as his friends and relatives. Physical culture is not only profitable to those who require to win their daily bread in the various industrial pursuits by which society is served, but is of much social and moral gain. It heartens and strengthens men for their employment; quickens their enjoyment by the vigour it imparts to their vitality; and imparts wholesomeness to the entire operations of the nutritive and the exertions of the bodily organs.

Many of the avocations of the rural and industrial members of society have a tendency to make them in some cases heavy in build and slow-footed in gait, and somewhat clumsy in their general movements, and in others over-developed in certain nerves and muscles, yet under-developed in some different way. Such want of balance in form and power may be wisely counteracted by a judicious adoption of gymnastic exercises, athletic games, and exhilarating pastimes. This brings into operative activity new and fresh habits to correct the evils induced by those previously prevalent, and the bodily form as well as the general health are improved in the process. But it is equally true that the increase of sedentary occupations and of businesses requiring intense and continuous application of the intellectual faculties has brought into distinct importance the necessity of having some systematic counteracting means of restoring the balance between the assiduous and often irksome exercise of the mind, or the equally injurious influences of the monotonous sameness of exertion and of operation due to the general adoption of the principle of the division of labour in every craft and employment. The diffusion and hearty encouragement of athletic training, gymnastic amusements, and well-ordered popular sports, pastimes, and games would rapidly aid in improving and invigorating the health and usefulness of individuals and the physical stamina of the race. Neither "riot, revelry, nor rout" are advisable, but a wise and discreet knowledge of the laws of hygiene, and a sensible yet scientific use of the powers of the bodily frame for the purpose of keeping in right order and activity, adjustment and interplay, the whole capacities of men.

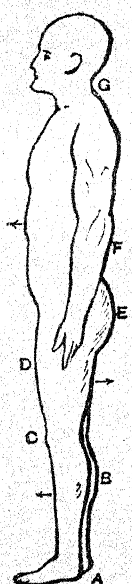
CHAPTER I.

STANDING—LEAPING—VAULTING.

MAN is the only member of the animal creation whose body seems so planned as to assume, naturally and characteristically, an erect posture. The skeleton and the muscular system of the human frame are expressly adapted to an upright position. This we regard as manly and speak of as commanding. The spine is not absolutely straight, yet all its curves are so arranged that when properly adjusted, a vertical line drawn from its summit would fall exactly on the centre of its base; and the thigh-bone is very securely fixed so as to support the body best when it is erect, and all parts of the frame are most adequately fitted for performing their respective functions when it is "well set up."

A good "set up" is of itself a matter of no slight importance. It regards the body as the precious casket in which all the powers of personal life and worth are contained. The equilibrium of all the portions of the body permits the greatest freedom of movement, the intensest concentration of force, and the utmost power of endurance, provided care is taken to relieve the muscles from exhausting fatigue by judicious variation in or exchange of the motions by which the perpendicular is preserved. Standing is really a series of complex muscular actions. While the body is in an apparent state of repose, it is really "on the stretch," being so sustained by the contraction of certain muscles that its upright poise may be preserved. In the annexed figure the body is shown in the erect posture. At A the feet rest firmly on the ground. To prevent the leg, A to C, from falling forward, the muscles of the calf B, which reach from the shinbone to the heel A, contract firmly so as to keep it straight up above the foot. Next, the thigh, C to D, if not upheld would bend backward, but that the powerful muscle at D contracts and straightens it. This muscle presses the knee-pan upon the thigh-bone and the tibia so as to close the front of the knee-joint at C. The body itself would fall forward but that the large muscles at E, which are fastened behind at the haunches, keep it in position, balanced on the thigh-bones. The spine segments are also sustained one upon another by the muscles of the loins at F, and those of the neck at G support the head. It is thus that, by a continued exercise of preventive contractions of these mutually-opposing sets of muscles, the erect attitude is maintained. The constancy of the strain explains why we become so soon tired when standing still. The dagger heads in the diagram indicate the direction in which the parts of the body have a tendency to fall if left to themselves, and the letters A to G show the muscles in which the compensative counteractions reside. The standing posture is an instance of the exercise of balancing under the influence of vital activity—the muscles by their action equalize the weight of the bones and steady them.

Fig. 1.



In standing, the entire weight of the body is borne by two feet placed firmly on the ground. The erect posture is best secured when the whole frame is brought as nearly as possible to the line of gravity, which passes vertically through the head, spine, pelvis, and lower limbs. The weight of the head and trunk is laid equally upon and transmitted by the two thigh-bones from the haunch-bone of the pelvis at the hip-joint to the knee, whence it is transferred to the two bones of the leg proper, the larger of which bears the greater part of the weight, while the smaller gives attachments to muscles and imparts strength to the ankle-joint. At this joint, the astragalus or key-bone of the instep of each foot receives its share of the weight, transmits it to the hinder pillar of the plantar arch, the heel, and diffuses it through the front pillar of the arch to the ball of the toes. In this way upbearing strength, as well as elasticity and springiness to prevent jar or shock, is secured and steadiness given to the foothold. In our chapters on PHYSIOLOGY (I. pp. 45-49) the bony structure of the frame, and (IV. pp. 226, 227) the muscular system engaged in upholding the body, have been carefully detailed and illustrated in the accompanying plates. On referring to these, it will be readily seen that shapeliness, grace of figure, and sustaining power of *pose* are promoted by six curves arranged alternately in front of and behind the line of gravity, at (1) the neck, (2) the back, (3) the loins, in the line of the spine and (4) in the pelvis, (5) at the hip-joint, and (6) at the knee. Exercise in maintaining stability in the erect posture and in accommodating the muscles of these different curves to preserving the equilibrium of the body in motion, under pressure and in strain, is now usually given in gymnastic drill and elementary lessons in dancing and deportment. In default of these, the self-instructor may take practice in the following way—place the body against a door or wall, as it would be applied to a standard for the measurement of height, sensibly touching, but not leaning on it, having the head steadily poised, face forward, shoulders square, chest well expanded so as slightly to curve the back, the pelvis evenly balanced on both limbs, the legs so close that the heels touch, and with the toes turned out so as to form a V shape. The arms should hang straight down, the elbows close to the body, the hands with the palms open towards the front, the thumb flat on the forefinger, and the little finger touching the leg lightly. Retain this position till the muscular balance becomes sensibly felt; then, advancing one pace, retaining or regaining the same attitude, steady the figure as long as possible, without irksome inconvenience, and thereafter, by stepping backwards, resume the position taken at first, using special care that no sensible muscular readjustment requires to be made in doing so. Repeat this process until the position called *attention* can be taken easily and maintained steadily. Having acquired this power, the body may be pivoted, as it were, lightly on the heels, at a point in the centre of a circle, which should be divided into four quadrants (p. 95); and standing on that point, the person, in the posture of attention, may be carried round into quadrant after quadrant so that in four equal pivot movements the return can be made to the position first taken; again, the feet may be moved successively to each point of the compass, touching with the great toe the edge of the circle at the end of each semi-diameter, and being replaced as before at each return of the foot, regaining both equipoise and erectness, until measured accuracy of foot movement and stability are attained. In order to ensure steadiness, in regaining equilibrium the feet, one after the other, may be opened to the extent of a semi-diameter and closed again, and then simultaneously, to ensure dexterity of keeping balance. The knees may be bent, carrying the body forward steadily as far as possible without losing equilibrium and brought back to erectness, then the body should be lowered gradually backwards, bending the knees until the position of squatting can be assumed easily, and the upright can be resumed steadily. Exercise in balancing the body may be taken by movements, simultaneous or alternate, of the arms and legs, standing on one leg, leaning forward, backwards, and sideways, as far as possible without losing gravity.

And all varieties of movements may be made with the upper extremities, first without and afterwards with dumb-bells, weights, &c., and the other movements of the body, stooping with one knee, then with both, in infinite variety. Thus suppleness, dexterity, and ease of deportment may be enhanced privately and at home, without other instruction than one's own ingenuity in experimenting with his various members as to the motions they can accomplish in an erect and standing position.

In the annexed illustration we show a figure (fig. 2) in a position which does not seem very gainly, yet the exercises of which it represents the completion of the series are of great value to those who are engaged in any occupation necessitating any constrained attitude. The body is first to be pivoted on one foot, A, the other being raised by slow degrees to B, the balance being regulated by the corresponding movements of the arms towards C and D; second, the same movements

are to be repeated, using the other foot B, and reversing the action of the arms C and D. Repeat the same motions quickly to and from the fixed points 1, 2, and 3. Next pivot the body on the ball of the toes and repeat the motions slowly, and gradually increase them in rapidity. Go on thus until you can *pirouette*, whirling round with the upraised foot at any elevation, and with the arms steady or in motion as you may desire. The exercise, when practised regularly for a time, until facility is gained, may be used with varying degrees of speed and force. By it all the extremities are trained, and the whole trunk is benefited by the quickening of the action of the lungs, heart, and abdominal muscles. The more constrained limbs are to be most frequently exercised, and if the chest is weak, a vigorous exertion of the arms in taking the positions will tend to strengthen and expand it.

As an effective exercise in gaining and retaining the balance, practise (1) standing erect on both feet close together in V form, with the hands by the sides, (2) raising the arms alternately and simultaneously with considerable force, (3) throwing the arms backwards and forwards till the circle can nearly be completed by each without stirring the feet, and (4) by gradually moving the feet apart from each, one forwards and the other backwards, as in the illustration (fig. 4), increasing the length of stride without deflecting from the straight line, and then widening the stride sideways, still keeping the centre of gravity.

Fig. 2.

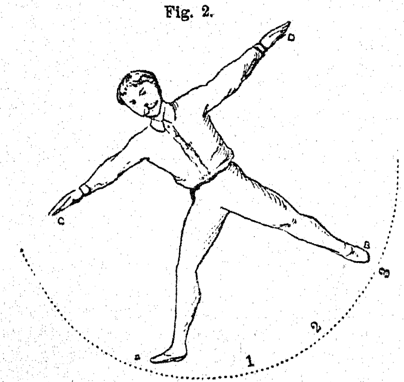


Fig. 3.

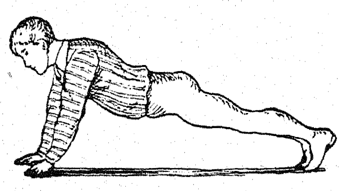
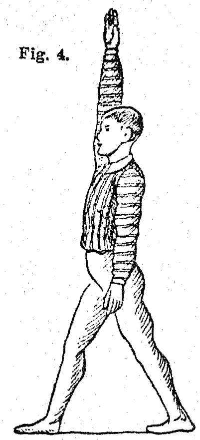


Fig. 4.



Chest strengthening may be secured by (1) laying oneself flat on the floor face downwards, (2) placing the hands under the chin, (3) raising the body on the arms till they are at full stretch as shown in fig. 3, and (4) by a forcible rebound from the hands bringing the body up to its feet in the erect posture.

The following simple exercises may be employed for improving the power of standing steadily and increasing the capacity of the chest:—(1) Stand with heels closed, toes properly turned apart, and having the body thoroughly erect; bring the hands, the palms being open, forward to the chest, so that the points of the middle fingers touch; then, ten times in succession, throw out the arms (*a*) straight from the shoulders vigorously, replacing the hands thereafter on the chest as before; (*b*) throw the arms downwards full length, touching the thigh alternately with open palm and clenched fist, and replacing the hands on the chest; (*c*) throw the arms upwards from the chest, closing the fists as they reach the perpendicular, and resume the position of the open hands on the chest; (*d*) repeat the three movements, successively closing each semicircular movement by bringing back the hands to the chest. (2) Stand similarly, then cross the arms over the chest, catching the elbows in the open palm; next throw the arms out to their utmost, palms open to front, turn the palms backward, and, carrying the hands behind, touch the elbows with the forefinger, and resume the former position.

These, though more difficult, are highly beneficial. Place the opened hands on the haunches, and standing quite erect with the knees perfectly straight, raise the body slowly and steadily on the toes as high as possible; keep the body thus balanced as long as possible, and then let the feet deliberately descend on the heels. Next, poise the body on the toes of one foot for some time, and then repeat the process on the other foot. Be careful to keep as upright as possible. Place the toes on any straight line, and having the hands on the haunches, kneel down slowly until both knees rest simultaneously on the ground. Rise up without removing the hands from the haunches or the toes from the original straight line.

Leaping, as an *act*, is accomplished by the bending and re-extension of the lower limbs and of the trunk. The first process is to *de*press the trunk upon the thighs, declining the buttocks hindwards towards the heels, and having the knees bent prominently in front, the heels being by the same movement raised from the standing ground, and bringing the entire weight of the body into poise upon the forepart of the foot. Simultaneously with this action the lower limbs are compacted to the utmost of their power of tension, and are thus held compressed and ready for a spring. The second process is to let this compressed set of muscles extend suddenly, so that in one single act, the extensor muscles, which form the greater portion of the lower trunk and the thigh, straighten out every joint to the full, at the same time that the foot springs from the ground, and in this way the whole body is projected into the air.

This upward standing leap ought to be diligently practised till the power of making the trunk and the lower limbs act harmoniously and simultaneously, and of recovering and preserving the equilibrium of the body is fully attained. The same position and action of the bodily frame are taken in the other special modes of leaping—forward, backward, sideways, and at different angles; but the direction of the resilient force is changed at the discretion of the will—making use at the same time of the arms as regulating pendulums to assist in effecting the course of one's change of direction. In leaping *height*, begin with a moderate force, increase it gradually, until the entire muscular force is under control. In leaping *depth*, the elastic spring of the muscles should be free, the body well balanced, and the descent should be made softly on the balls of the toes, to prevent jolt or shock. In leaping *width*, care should be taken, in early practice, to progress gradually upon soft grass or ground strewn if necessary with some soft material, as sawdust, in case of falls. Every descent should be made feet foremost with heels raised, the whole body yielding successively to the resistance of the ground—the limbs pliant, knees bent, the trunk carried forward, and having the hips pressing towards the rear, so as to diffuse the shock in lessening power as the body regains its equilibrium.

In learning to leap *height* and *distance* combined the objects over which the leap is to be made ought not to be firmly fixed, but should yield readily to a slight touch if the leaper fail to go clean over. Two standards, one having feet and inches distinctly marked on it, the other having holes at inch distances for receiving small pegs, best answer for gauges. A light bar resting loosely on pegs on the side of

the upright farthest from the leaper is perhaps safest and best. See fig. 5.

To leap *on* to an object, which ought to be solidly based that it may bear, may be done (1) standing, (2) running. In the *first* (*a*) throw the arms to their full extent up over the head, (*b*) close the hands, (*c*) bring them down again to full stretch by the side, (*d*) bend the knees till they over-jut the toes, (*e*) raise the heels, and (*f*) poise the weight and downward pressure of the body on the forepart of the feet.

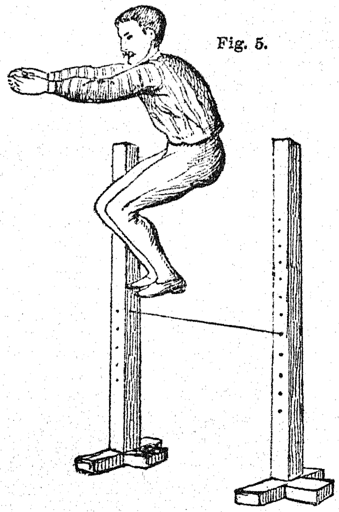


Fig. 5.

Repeat these movements three times so as to accumulate vibrant force, then leap from the feet so as to rise above the object in height, and alight upon it with the front part of the feet, having the knees well bent forward, and bringing the trunk low down towards the heels, with the arms close to the sides at full extension as balancing and steadying weight-powers. Having gained mastery over these movements, the leap, by giving greater propulsive force to the feet, will take the leaper *over* the object, but he must be careful to descend yieldingly on the balls of the toes. In the *second*, instead of seeking propulsive force by the three flexures of the frame, the leaper may attain an accumulated velocity which shall aid and further the impulse of the leap by a previous run, at the close of which he knits and compacts his frame for the forth-going spring, managing the bodily movements for and in alighting or overleaping as previously directed. In leaping sideways or to any angle, we require to measure keenly height or distance by the eye, and taking care to plant the feet properly, to spring smartly, and to use the arms with an inclination towards the direction in which the leap is made. In leaping length alone from a hail or mark, throw the arms forward and upward till they are in nearly perpendicular line with the shoulder, with the hands closed; next bring them down and throw them as far back as possible at their full stretch, bowing the trunk and the lower limbs meanwhile as for a spring. Repeat this preliminary process thrice, and instantly, with all the power and elasticity so developed, throw the trunk forward and spring off, not rising too high, and when descending bring the soles of both feet yieldingly to the ground, retaining the heel in its place till the distance is measured, or marked for measurement. In a backward leap place the heels at the edge of the starting mark, repeat the extension movements, only that when at last throwing the hands with all your might rearwards, open and palm upwards, you spring from the feet, and, while descending, bring the hands down to the sides, with their palms downward somewhat to the front.

Hop, step, and leap is a complex effort of agility. It includes three different processes of muscular exertion performed in unbroken series—(1) a *hop*, in which the athlete, poising himself on one foot, so leaps as to raise and carry forward the whole weight of the body and to alight on the same foot; (2) a *step*, in the course of which, from the foot on which he alights, he moves forward and alights on the other foot; and (3) a *leap*, in which, rising from the foot just put down, he carries forward his body and alights on both feet. This exercise requires special care in managing the balance of the body, so that the lean of the weight on one side may counterpoise the weight of the inactive limb on the other. The centre of gravity needs to be so adjusted that a steady alightment may be made, and the step may be instantly taken readily and easily with the forward going foot prepared to receive and bear the transferred weight, yet, during the progress of the leap, so to rearrange the burden that a steady alightment on both feet may be finally accomplished. Many slight and often whimsical modifications of the normal form of this exercise are made in competitions, most of them having for their object to increase the difficulty of readjusting the muscular force in the course of the threefold change in the balance of limb and frame. No general guidance can be given by empirical rule for accomplishing this feat—personal size, weight and build, possible and manageable muscular force, fineness of nerve-power, and dexterity in concentrating it must all be taken into account. Practice alone makes perfect in making each person sure of the means and power he possesses of maintaining, or in case of disturbance, regaining the equilibrium of the body and the forces of movement. The results of the immense bodily strength and cultured adaptability conjointly required in this exercise on record vary from 44 feet to 48 feet 8 inches.

High leaping is generally prefaced by a run. Some take this in a straight line towards the bar, many at right angles to it, and others at various other angles. In styles, too, they differ; some take a right foot rise, others a left one. Some cross the bar with knees bent and heels and hips nearly on the same level, others as if sitting with their legs stretched out at full length; many bend up the knees towards the chest and go over with both feet, while others appear as if sitting hams and heels together, and we have heard of one who dashed head foremost over the bar like a diver taking a header. Experts differ in opinion of these styles. They probably suit best those who employ them. But connoisseurs regard as the most graceful and effective that form of high leap in which the athlete, as the body rises, draws the right leg up first, brings on the left so quickly after it that the body gets a "secondary impulse" just as the feet are going

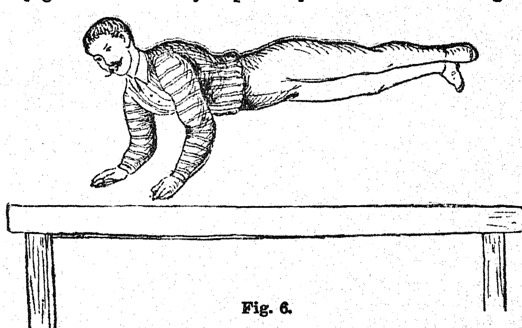


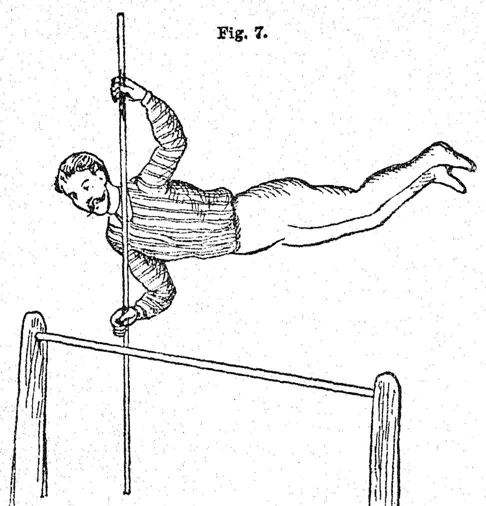
Fig. 6.

over, then by bending down the left side, turns hip and thigh clear over the bar, and descends *à plomb*. See fig. 6. The records tell us that in this way some athletes have succeeded in "passing the bar" nearly three inches higher than their own stature. A leap one's own height is a good average, even for professional athletes, when the ground is level and the crossbar perfectly horizontal, and the take-off is made from short grassed turf and dry soil. If the soil is rich and moist, and either over or under grassed, the take-off is deadened.

Pole vaulting is an excellent exercise for the strengthening of the muscles of the arms, chest, shoulders, and upper spine. It looks arduous and dangerous, but it is really neither—in fact it is not so severe in strain as long-leaping is. Of course, the muscles must be strong in fibre and pliable in mass, and the vaulter should be sure of his mastery over them. It is a most important matter to secure a good pole capable of bearing the strain to be put upon it, which will vary with the weight, agility, and dexterity of the user. Well straight-grown, knot-

less, and not cross-grained pine, is the best for the purpose. It ought to be light, easily used, tapered off at each end, but having the lower one sharper than the upper, that it may not slip should the ground be hard or dry. Its thickest part ought to be somewhere between 3 and 6 feet from the ground. The pole is generally grasped with the fingers of both hands, the upper hand being a little higher or lower (as suits the vaulter best) than the height he is to clear, and the lower one, 2 or 3 feet beneath that. Some grasp the pole with the

Fig. 7.



fingers of both hands turned upwards, but others turn the fingers of the lower hand downwards. Having caught the pole thus, the vaulter takes a run, increasing in its speed till he has reached between 3 or 4 inches and a foot or more, from an imaginary line drawn between the uprights. There he plants his pole. The impetus of his run enables him to throw his body upwards, so that when nearing the crossbar he can project his body over it, and throw the pole backward to fall clear of the bar, himself alighting upon the farther side.

It is usual in amateur athletic contests, in leaping, jumping, vaulting, hop, step, and leap, &c., to allow of three "tries." If any competitor overpasses a given height or distance, any other competitor who does not equal that in these three tries is "out of the contest." In many trials of feats of strength and agility a run of 7 to 9 feet is allowed, but in jumping there is no fixed limit for the preliminary run. It ought not, however, to be taken too long, lest it exhaust the lungs or limbs too much before the final effort.

CHAPTER II.

WALKING—RUNNING, ETC.

Walking is a compound act. It starts from the standing posture, and consists in definite alternating movements of the lower limbs. It is physiologically defined as a series of partial forward falls, checked just in time to prevent a complete downfall by the forthputting of one or other of the lower limbs to readjust the equilibrium of the body. While one foot is retained on the ground the other is extended, carried forward, and placed at a short distance to the front. Thereupon the sustaining foot proceeds to lift itself, places the weight of the body on the steadied leg, and swings itself forward as the former had done. When one leg is raised the supporting surface of the body's weight is, of course, diminished one-half, for the sole of one foot only now forms its sustaining prop. The upper part of the trunk requires to be slightly inclined towards that side on which the weight is laid, and this interchange must be so deftly made that the common line of gravity shall fall with absolute accuracy on the limited surface of support which the single foot for the time being, however brief, affords, otherwise swaying will occur and liability to fatigue will be the consequence of any error in the counterpoise of force. Any avoidable degree of shifting in the centre of gravity increases the difficulty of maintaining the weight of the body on a variable surface of support. The accurate adjustment of the flexions of the muscles, the minimizing of the shift of gravity in taking a step, and the smallness of the arc of the swing of the foot in progressive movement, are all points requiring the utmost care in walking with a light, easy, and graceful footstep.

A *pace* in walking is the distance passed over at a stride by the foot from the point at which the heel is raised to that at which it is set down. In "slow" marching time its length is averaged as 30 inches; in "double time" 36 inches is counted the average. In "stepping short" 21 inches are taken, in "stepping out" 33 inches. It is well to know, as regulative aids in timing practice, that in slow time 75 paces per minute, in quick time 116, and in double time 165 are professionally taken.

As a preparatory exercise prior to taking the pace, it will be found useful to stand easily on one leg and fling, or rather swing, the other leg backward and forward, (1) keeping the sole of the foot close to, but never so close as to touch, the ground, (2) raising the foot gradually higher, though still swinging it freely from the hip-joint, and from the knee alternately, and (3) placing the tip of the great toe before, behind, and to the side—at 12, 21, 24, and 30 inches in succession. Repeat these exercises standing on the other leg.

What is technically called "the balance step" is deserving of careful and frequent practice. It is the most essential stage in the preparation for skilled and scientific walking. It is best first practised on a stationary point, from which the foot may be moved forward or backward, and to which it should always return. Its object is to attain the free movement of the legs, while maintaining the steadiness of the body and retaining the shoulders square to the front and well forward. Proceed thus: (1) raise the *left* foot from the ground by a slight yet jerkless bend of the knee; (2) pass the foot forward gently towards the front, gradually straightening the knee—retaining the foot at the same angle as that with which it started; (3) keeping the sole of the moving foot parallel to yet clear of the ground, bring the heel just on a line (which you may imagine to be drawn straight across and at right angles) with the point of the great toe; (4) carry back the foot gently, clear of but parallel to the ground, till, the left knee being slightly bent, the toe comes into line with the heel. Repeat these front and rear movements of the left foot, with shoulders square and body steady, as long as possible, counting up to 6, 10, 16, 24, and so on. Use the right foot in the same manner, and continue the practice time after time, till ease, steadiness, and evenly movement have become habitual and almost unconscious. Repeat the same movements on a distance marked 30, or any other convenient number of inches, from where the heel of the one foot is stationed to that which the heel of the moved foot is to reach.

These exercises constitute an excellent preparation for walking, to which it may next or afterwards be applied by stepping forward with the left foot 30 inches, then the right—observing carefully that the heel of each foot should be placed on each side of an imaginary straight line, forming the line of route on which progress is to be made. [In the early exercises the pace-length and the route-line may be marked in any convenient way.]

A valued contributor, who has from his boyhood used, and loved to use, his legs, says—"One may be a good, without being a great, walker. I have never done what might be called a long day's walk. Seldom have I exceeded 30 miles, but I have often covered 25, and felt as fresh on ending as at starting. As it is upon the feet that, in walking, the stress of exertion falls, they first require consideration. The legs and other portions of the body do indeed bear a share, but really, in comparison, only a minor share. Therefore we have to make and keep the feet as comfortable as possible. This can be best done by wearing well-formed shoes, with good thick yet flexible soles. The upper leather may be strong, but it should be soft and flexible. If it is hard it will be sure to

blister the feet, and then farewell comfort and pleasure too. As it is the latter that I walk for, so soon as the feet begin to blister the sooner one gets home the better. Some prefer to walk in boots, and I daresay there is little to choose between them, only shoes are lighter and heat the feet less. Whichever are worn they should fit properly. They must not be so tight as seriously to compress the foot, and yet ought not to slip up and down, for then the skin will in a short time fray. Then comfort is gone and fatigue sets in. It is almost superfluous to say that we should never attempt to take a long walk in new foot-gear. David refused to go up against Goliath in the armour Saul offered him because he had 'not proved it,' and I would advise everyone to decline to go a walk in shoes which he has not *proved*. Some pedestrians, I know, think that even strong-soled shoes or boots should have their soles well-studded with sprigs or nails; but to this, if walking on ordinary country roads, I attach no importance. On beaten tracks being left, and especially in hill-climbing, sprigs are, no doubt, of great advantage. On the whole it is better to have them—they are never in the way, they do not retard speed, and certainly they prevent the foot from slipping when one takes to the hill.

"I do not hesitate to advise that, in walking, good thick stockings should always be worn. It is a mistake to walk in flimsy ones—they do not absorb the perspiration, and they harden on the feet, which at once blister. Before setting out for a longish walk, select a good thick pair of stockings, that have not been darned, as however well it may be done a darn is apt to fret the foot. Stockings are unlike boots or shoes, one does not require to prove *them*.

"I have little to say about the *rate* of comfortable walking, so much depends on physique, on condition, on time of life, occupation, habit of body, season of the year. Healthy persons of light and compact frame seem to benefit from a good deal of brisk exercise. Even the weak, however, can, by care and regularity, improve their strength, while the heavy, by a judicious course of self-management, may astonishingly lighten their weight and brighten their days, if they pursue it prudently. Indeed, in walking, as in so much else, it is wise to go on by degrees, and increase in speed as experience counsels. It is unwise to set out too fast. A good round even pace will enable one to cover more ground in eight hours, than if, by setting out too fast, he early overtasks himself. When I was younger and lighter—I am now somewhat over fifty and can scale close on 15 stones—I could easily maintain my 4½ miles an hour, and could keep up that rate for several hours without feeling the slightest fatigue. On the very day of this my writing, I walked 16 miles, at 3½ miles an hour, and covered that distance without any sense of weariness. I reckon that, with an eight hours' walk before one, a good pace is from 3½ to 4 miles an hour. As beginning in overhaste overquickens the circulation and tends to tire the muscles too early, so hurrying up at the end is apt to expose the body to chill and stiffness. The wise walker takes care to give the blood time to resume its ordinary current rate, and to take steps to prevent it from being arrested by cold in the small vessels, and thus inducing stiffness of joint and muscle. On this account I recommend that after a walk a bath be taken, or that, at least, the feet should be bathed. It soothes and comforts at the time, and it acts as a preventative of chill or any other ill effect from over-heat or over-exertion."

No mode of travelling gives so much enjoyment at so small a cost, or with so little mixture of alloy. As an exercise it has many advantages; it is within almost everybody's power; it can be taken with little trouble; it is available when other means are not at hand; it is an effective and a very independent mode of locomotion. Walking for a walk's sake is beneficial as an exercise; but it is made doubly so when the scenery through which we "jog on our footpath way" is attractive and presents something to engage thought and gratify the mind. It is made animated and delightful by congenial companionship, or when the road is but an invigorating stretch between friend and friend. The best tests of the advantages of walking are the keenness of appetite it provokes, the restful sleep it promotes, and the brisk alacrity of mind it induces. Carry a well-informed mind with you in every rural tramp; observe the scenery through which you pass, note the suggestions which arise under the influence of sunshine or shower, plant-crowded valley or wood-crowned height, trickling streamlet or hedge-bordered pathway; enjoy the influence of spring blossoms, summer flowers, autumnal orchards and harvest-laden fields, or winter's freaks in snowflakes, delicate traceries in frost or glittering expanses. Have in your hand, if so inclined, a well-balanced stick, but do not let it interfere with supple joint or springy foot. Walk with the unhelped freedom of trained muscle and unstrained sinew with a well-timed pace, which gradually succeeds in covering, at the anticipated time, the intended space—never over-exhausting lung or limb, and never permitting laggardness to overcome energy.

Though walking supplies a pleasant and beneficial exercise, competitions in walking are rather ungainly and exhausting. One has to set himself to accomplish "heel and toe" progress. The one *heel* must touch the ground before the other is raised and the impulse of the toe is taken. Thus "one foot or other must always be on the ground." The knee requires to be straight when the foot is lowered or lifted, and consciousness of the stretch on muscle and the extent of stride intensifies the feeling of fatigue, and the muscles crave relief. Some walkers have the knack, just when the limb is raised on the ball of the foot and the trunk is poised on the top of the thigh-bone, of dexterously rolling off the superincumbent weight as the raised foot swings, and by a twist of the hip securing a light and lengthy step, to the great ease of the muscles, which are required at once to flex and bear in the act of taking step. This gives some advantage as a change, but has its own disadvantages when habitually used.

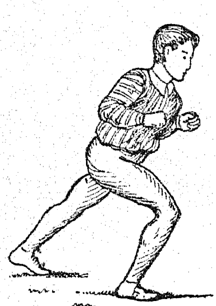
Both in walking and running two points need more attention than they usually get—(1) freedom and length of stretch taken at a pace, and (2) speed and agility of muscular movement. The length of stride, of course, depends in large measure on original length of limb. This, if inherited and wisely used, is a very great advantage, and yet we find many men in possession of lengthy lower limbs who do not make full use of their natural gift, and by disregard shorten their steps, sometimes even to mincingness. Extent of pace is of vast importance, and strenuous endeavours should be made to secure its freeness and extension. This may, in some measure, be improved by exercising the joints and muscles by which the lower extremities are attached to the trunk. As regards rapidity of step a great deal can be accomplished by training and practice. Swiftness of contractility in the muscles and suppleness of motion in the joints can be acquired by diligence and effort. The gain of an inch in length of stride would save a considerable number of steps in a mile's walking.

Walking on Stilts.—This is a recreative exercise with much to commend it, especially as affording development to the upper limbs, practice in steadiness of poise, and general gentle muscular culture down the whole frame equally on each side. The stilts are two poles, stout, light, and of a serviceable height. To each pole there is attached, at such a height as is most suitable, a semi-wedge rest for the foot. The best method of fastening these is by screw and bolt. The holes may then be graduated on the pole, and the height may be altered from low to high as required. It is reckoned useful to have graduated catch notches in the upper part of each pole for convenience of grip. The whole art of stilt-walking consists in lifting each alternately with the arm and hand, when a step is to be taken, and using care in preserving the equilibrium of the whole person on the rests. For this, diligent practice is necessary, that ease, confidence, and security may be gained. In rambling expeditions the power of walking on stilts is very useful in exploring marshes and bogs, wading through muddy places, or crossing shallow sheets of water in river courses, or between islets. In botanical excursions, ornithological raids in search of eggs, or making collecting outings for other objects, stilt-walking is a useful accomplishment, as a vasculum, a box, or a canvas bag, may be so slung over the back as not to impede progress and yet convey the treasures, whatever they may be, procured in the expedition. The exercise is peculiarly valuable, because it can be practised alone or in company, and gives safe exhilaration and change. Great amusement may be found in perform-

ing many balancing feats on and with the poles, and sometimes walking and even racing competitions in stilt-walking may be made a source of enjoyment.

Running.—Running is in reality a closely-connected series of the movements already described in walking and leaping. The body in walking is always supported on one or both legs; in running, the feet are in such rapid motion that they are never both on the ground at the same time. At regularly recurring intervals the feet are not in contact with the earth at all, and the body moves freely for the time being in the air. The advancing foot is not placed on the ground at the same time as the hinder one quits its position. In this it differs from walking and approximates to leaping, inasmuch as the impulse of the leap is carried into the motion of the walk. The instants of leaping are, of course, diminished in duration, and are taken advantage of only by one foot at a time. By this means, the bound from the one foot assists the rebound from the other, and the moments of impact of each foot on the ground being lessened as much as possible, we have a more rapid passage through space; each leg, as in turn it becomes the supporting one, loses as little time as possible in the act of impact, and prepares for its swing beforehand; the runner's impulse gathers strength and increases speed so long as the flexors and extensors can keep up their vital elasticity in the contest between motion and gravitation. The runner must not let his foot go flat on the ground; that takes up too much time and consumes too much force. The more lightly the footfall is made on the ball of the toes, the more speedily may the rebound from the ground be made. In the rapidity of pace required in running, the heart and lungs are severely taxed. Hence good runners throw their shoulders well back, straighten the upper part of the body, so as to enlarge the chest by widening the ribs; and thus secure at once a larger capacity of lung power, a better aeration of the blood, and a stronger action of the muscles, because the supporting basis is broadened and steadied. The runner, while trying as nearly as possible to skim the surface of the ground, must carefully attend to the preservation of the centre of gravity. The risk of losing one's equilibrium increases with the speed of one's career. Here the arms offer a counterpoise. They hang like weights on either side of the trunk, and may be used as regulating pendulums. When evenly balanced and held symmetrically they do not affect the lateral equilibrium. While they swing backwards and forwards in their reverse action to the legs—each going backward at the same moment as the leg on the same side moves forward—the centre of gravity readily adjusts itself. But if one of the upper limbs be moved into a different position from that of the other, the distribution of the weight is altered and the centre of gravity changed in place. This alternately inverse movement of the upper and lower limbs—in walking, leaping, or running, wherever the force of counterpoise comes into operation—is a most important aid to speed. The body, indeed, instinctively adjusts itself to the laws which govern it; but it is not wise in us to neglect learning these laws and conforming in our voluntary movements to their requirements.

Fig. 8.



It is much more difficult to become a successful runner than a good walker. Most men—unless they suffer from some physical defect, or their avocations are not of a strictly sedentary nature—can manage to do a somewhat fair day's walk; but few can run well, unless they devote considerable attention to the task of accustoming themselves to concentrating their whole strength, at the required time, in the right way for the accomplishment of any special exertion of speed and endurance. Men ought always, in ordinary health and circumstances, to be in fair walking condition. Walking must be a regularly recurring part of one's habitual duty; running is, in general, only an occasional necessity, and even as an exercise with some ulterior object in view, is not one practised every day, although, as a help to the habit of taking pains and keeping wind and circulation under control, the doing of a daily distance of from 30 to 40 yards at a fair, but not an over-straining speed may not be inadvisable.

To be in or to get into fair running—or perhaps, we should say, *racing* condition—it is necessary to undergo a considerable amount of training, which involves some self-denial; in fact, one must live by rule. The aim of training is to gain and store up physical strength in accordance with the laws of health. This requires care in eating, temperance in drinking, regularity of habit and exercises, and, above all, constant practice in the performance of those feats in which one desires to excel. Whoever requires much more than these simple and steady-going ways—traditionary dieting and specific medicines or the like—will never attain great benefit from, or success in, athletic sports and pastimes. It may not, however, be without use to give the reader the benefit of knowing to what measures resort is had, for weeks before a race "comes off," to bring the body "into subjection." Besides careful dieting and regular appropriate exercise, the keeping of good hours must be strictly observed. "An hour's sleep before twelve is worth two hours' after it" applies particularly to the man in training. He should not be out of bed after 10 p.m., nor in it after 7 a.m. Donning some loose light suit, good socks and shoes, let him issue forth before breakfast for a sharp, spirited turn of two or three miles, according to strength, time, and weather. The best amateur runners whom we have known have always attached the greatest importance to early, regular hours—more so even than to strict dieting. It is really useless to go in for distance running unless proper attention is paid to both. General suggestions upon diet in training are quite superfluous, especially to those who practise athletics as private pastimes. One may refer, however, to the way in which the Oxford and Cambridge crews were dieted while in training. Ardent spirits were strictly avoided. One glass of beer was permitted at their 2 o'clock dinner, and one of the crew was indulged with a small glass of port. Soups, pastry, and potatoes were entirely prohibited; but green vegetables, light puddings, and stewed fruit were allowed. For supper, which was light and partaken of early, beer or barley water was, in restricted quantity, conceded. Their solid food consisted of chops, roast beef and mutton; but boiled beef and mutton were forbidden. Tea found no favour in their eyes. It is essential that the action of the alimentary canal be healthy and regular.

The practice to be taken must vary with the distance to be undertaken. An ordinary sprint distance is 100 and does not exceed 440 yards. Races of one-fourth, one-half, or a whole mile are common enough—sometimes 2 or 3 miles are put in the programme, and in noted contests even 10 miles are fixed upon. Hurdle-races and steeple-chases come in as varieties, but mainly in professional sporting exhibitions. For a sprint, as defined, the preliminary exercise to be taken is steady walking for somewhat less than two hours, at an average rate of 3 to 4 miles an hour; running quickly, but not hurriedly, in some part of the course, about 200 yards going and returning; but as walking tends to stiffen ankles and knees, this practice should be given up ten days or a fortnight before the date of the event. As muscular *soft*ness gives place to firmness, one may decrease the length and increase the speed of his daily run, till he is able to spin off his sprint with tip-top nimbleness. "Hurry slowly" at first, but keep pressing onward in speed as muscle strengthens and breath-movement lengthens, till winning power is gained; and keep a good record of where, in the distance named, you need caution and endeavour. In longer runs, stamina is as important as pace, and therefore the runner should keep himself in good trim, and only once in each preparatory week expend from two-thirds to three-fourths of his real power, and husband his strength during a few days before that of the actual contest. It may be interesting to note that $1\frac{1}{2}$ mile has been run in 6 mins. $43\frac{1}{2}$ secs.; $2\frac{1}{2}$ in 12, $6\frac{1}{5}$; 3 in 14, $19\frac{1}{2}$; $3\frac{1}{2}$ in 17, $2\frac{1}{5}$; 4 in 19, $25\frac{2}{5}$; 6 in 30, 40; and 10 in 51, $6\frac{3}{5}$.

Any race—especially a long one—must be run with judgment, so as to regulate power and pace wisely from the start to the finish. The runner must calculate his strength, endurance, and power of speed, and know how to use them most economically and to the best advantage, as compared with his competitors. There are few finer sights than to see a *scratch* man win a long race, in which he has given twenty or thirty competitors a good start. It is interesting to watch him closing in on his rivals. He seems, at first, to have started at a slower rate than they, and probably so he has. But look at the manner in which he holds himself, and the long, steady, unvarying stride with which he covers the ground! This begins to tell before the race is half over; and, before three-quarters of the distance has been traversed only two or three are ahead of him. These, too, he sees are held in hand; and when the final lap comes, one notices the distance rapidly diminishing. It is, however, when the last 100 yards are entered upon, that the champion rushes to the front and breasts the tape a couple of yards or so in advance of the second in the run. Not much that, you will say, in a long race; but two yards "count a win" as well as a hundred.

One great point to be observed in any competitive race is the manner of passing your fellow-runners. If you start scratch, or near it, with several men ahead of you, it is often a matter of considerable difficulty to get past the men who precede you without having to go three or four yards right or left of them. These few yards, if the operation has to be repeated several times in the course of a race, tell. You must carefully watch your opportunity and be ready to avail yourself at once of a favourable opening when it offers. One runner we knew was very clever at that. We used to watch him eagerly, waiting his chance when three or four were close ahead of him. On the slightest break in the forerunners he quickly filled up the gap, till on another opportunity occurring, he took again a more forward place. He was scratch man for two or three years; and, though he gave big starts, he generally managed to breast the tape first; but he always asserted that he owed his success to the manner in which he ran the race; and we have no doubt he was in this greatly guided and aided by his cool and steady judgment. A short-distance runner should direct his attention, both in exercise and in practice, chiefly to *starting*. The start in a short race is everything. One second means ten yards to any noted runner; so one must be "off in less than a twinkling" when the pistol fires. We have seen athletes—two we chiefly remember—whose start was wonderful to see, so instantaneously rapid was it; they seemed as if they had been fired from the pistol!

The proper pose for starting in a foot-race may be thus distinctly stated:—(1) Let one foot—by usual preference *the left*—be placed about 9 inches in front of its fellow; (2) this (*left*) foot should toe the line and have the weight of the body balanced on it; (3) the other (*right*) foot should just touch the ground with the toe-tip, and be ready to swing off freely the instant the word is given; and (4) the trunk of the body should be held leaning slightly forward. It is advisable to practise this position carefully, and to exercise oneself in taking an easy yet instantaneous start, in such a manner that the right limb shall take the pace nimbly and the whole frame be carried forward lightly by simple propulsion from the toes of the alternating feet.

As to running costume a word may do. As the less he carries the swifter will he go, the more nearly his costume approaches that with which Nature has furnished him the better—the becoming being duly heeded. The shoes ought to be of the very lightest description, made to fit the foot like a glove. Runners' shoes are specially made by adepts—sporting shoemakers. They are generally made with six spikes in the sole to prevent slipping; but we have known runners who prefer shoes without spikes. Let me, in closing, say, that no person should go in for racing competitions unless he is distinctly sound in heart and lungs. Athletic contests bear hard on weak organs, and irreparable mischief may be done by overstrains quite unwittingly unless the muscular system is in good condition, and all the abdominal viscera strong, healthy, and free from fat. Even when every care has been taken in preparing his body for efforts in racing contests, no one should continue running too long. There is a great tendency, and often much temptation, among successful or ambitious athletes, amateur and professional, to overdo themselves. The exertion it demands is apt to tell on the constitution, however strong, and take the elasticity out of it. This should be specially remembered by long distance runners. It is a physical impossibility to continue running four or five miles every week for any length of time without injury, which stales the life out of which pith and pleasure have been taken. This caution is quite as necessary for the man who practises athletic feats for healthy pastime as for him who does so to gain honour and money as a prize-winner.

Since the introduction of "the walking track" and "the running path," and their adoption by the amateur athletic clubs at their championship meetings, much better opportunities of attaining excellence in these simple but effective forms of recreative exercise, and greater inducements, have been held out for undertaking training and acquiring knack and pith for these pastimes. The general use, too, of athletic clothing and club-costumes has led to much improvement in the practice of these wholesome pursuits. These facilities have favoured competition, created interest, and stimulated organized efforts for the acquirement of experience. They have, moreover, been taken under systematic supervision, and been brought under administrative law. On the programmes of matches, competitions for fixed (1) distances or (2) times now regularly appear, and the following laws have been agreed upon and applied:—(1) "Anyone starting before the word has been given may be put back a yard at the discretion of the starter," and (2) "Wilful running and jostling disqualify the offender."

An indispensable condition of gaining the full advantage of physical exercises and out-door recreation is that we should attend to the regular and healthy action of the lungs in respiration (see PHYSIOLOGY, chap. IX., p. 706). On this depend, practically, the true enjoyment of the buoyant vitality and the capacity for duty which enhance existence. On this account we recommend each student of athletics to acquire the habit of breathing well. This habit may be readily gained and easily kept up, and it will be found exceedingly beneficial in preserving the general health. Early each morning, on rising, while the chest is free from braces or pressure, inhale by the open mouth as large a chestful of fresh air as you possibly can, so that you may feel that it has reached and inflated the whole of the air-cells of the lungs. Then while the lungs are thus fully expanded close the mouth and through the nostrils breathe forth the air as slowly as you can, gauging by watch or clock the time that elapses from the first motion towards inspiration to the latest issue of expiration. Repeat and continue as long as you can, without inconvenience, this alternate and deliberate inhalation and exhalation each morning until the exercise becomes easy and pleasant whether performed in the house or in the open air, taking care, of course, not to overstrain the lung-tissues. After facility has been acquired in doing so, reverse the process, inhale and fill the chest through the nostrils, while keeping the mouth firmly closed, and then when entire inflation has been accomplished, breathe out, as slowly as possible, through the lips. Having practised this till the result is satisfactory, accustom yourself to dilate and empty the lungs by these processes alternately—(1) inhale by mouth, (2) exhale by nostrils, (3) inhale by nostrils, and (4) exhale by mouth. The lungs having been brought by these exercises under the power of the will as much as possible, after taking in breath to the full extent of the lungs' capacity, train yourself to hold in the breath as long as you can before allowing the process of expiration to commence—timing the interval elapsing between each completed act of breathing. This will enable a better supply of residual air to be retained in the lungs as funded capital for use in aeration. Thus the lungs will acquire the habit of adjusting inspiration to exertion, which will become almost self-regulating, and confidence in "holding out" while walking, running, leaping, diving, swimming are being engaged in will be safely attained. Such exercises, too, by securing the more perfect aeration and renovation of the blood, will impart health and vigour to the heart, brain, and entire system

CHAPTER III.

FLOATING—SWIMMING—DIVING—PLUNGING.

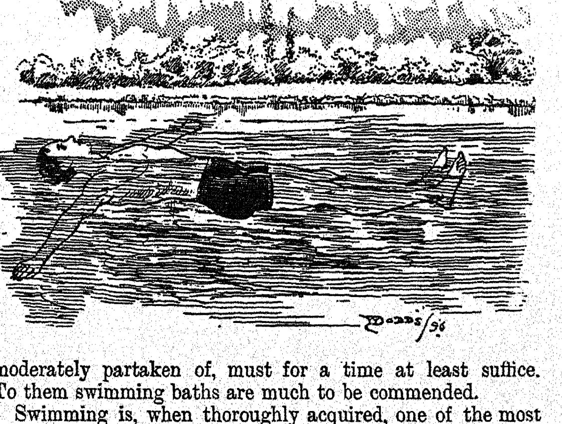
Floating.—That a floating body displaces a weight of fluid equal to its own weight, is the law of flotation. To acquire such mastership in floating as to be able to lie upon the surface quite at will, either drifting as the water sways, or taking advantage of its buoyancy to enjoy the soft and easy movement it affords, while simply piloting oneself as his taste for disport inclines, in the cradling rise and fall of the fluid, is a training dependent on this scientific principle—"that a fluid sustains as much of the weight of a body immersed in it, as is equal to the weight of the fluid displaced." Sea-water has a specific gravity of 1·03, fresh water being taken as unity; the gravity of an average adult is 1·06 or 1·07. Hence normally the human body, merely as a dead weight, will sink in either sea or river water; but as the living man, by drawing air into his lungs, can alter his specific gravity to some extent, he has thus, so long as he retains the power of inhaling air freely, the power to keep himself on the surface of the water easily, especially if he makes use, from time to time, of appropriate bodily movements as an additional aid. Regarding this matter, one may state, further, that the specific gravity of the whole body is determined by that of its particular constituents, as compared with their absolute quantities. Hence any disproportion in the amount of its solid structures or tissues, as bone or muscle, will heighten the general specific gravity of a body, and it will be lowered by deposits of adipose matter. Fat possesses a specific gravity of ·932, and is the only component of the body lighter than water. On this account persons of plump and rounded figure exhibit a lower specific gravity than those who are thin and spare. They therefore float with greater buoyancy. This is the true scientific basis for the fact that, if every part of the human body, head, trunk, and limbs, is placed fully outstretched, back downwards, on the water, the water will support the body, and will leave the nose and mouth free for breathing, without any special effort on the person's part. When this is realized in experience as a fact, floating is easy, and the master-key to swimming has been got hold of. Convinced that his immersed body is safe if he only remains still, he will add to his security if he learns to arch his back, keep up his chest, and hold his head well back in the water. If, however, yielding to a natural impulse, the person lifts his head, and with it, as he can scarcely help doing, his feet, and perhaps also his hands, he alters entirely the safe position, loses the ability to breathe, and therefore sinks. To avoid this, he should try such expedients as these—lie on the grass,* or on the floor, and learn to arch the back with the hands prone by the sides; practising at home, lean the head backwards over a chair, and have the conditions of flotation fixed in the memory—(1) body stretched fully out, (2) spine arched, (3) head thrown back, till even the forehead is covered, (4) feet still, (5) arms by sides, palms turned flat downwards. In a bath at home, or in any quiet place where shallow calm water is to be had, let these movements be carefully made, under the eye and with the aid of a protecting friend, who may, in the early trials, lay his right hand under the back to keep it arched, but not to support it, and hold up the chin with just the tip of the forefinger to keep back the head, as shown in fig. 9; and when he has learned to attend to all these conditions on merely hearing their numbers, he may be allowed to place himself flat on open water with head shorewards, and realize for himself that the water will sustain his body if he acts faithfully up to what he has been taught. Any one carrying out these instructions will be quite able to float in sea-water; but large-boned muscular people, especially men, who are usually heavier in proportion to their size than women, may not be so easily able to float in fresh water. If, however, the arms and hands are stretched out so that the body is spread over a greater surface of water, most people will find that floating can be accomplished easily enough. This will be greatly aided if the arms are stretched

Fig. 9.

straight out from the shoulders at right angles to the body, having the hands, with the fingers close together, turned downwards and flat, keeping the thumb side as it were the centre, and by working from the wrist, making a quarter circle with the little-finger side in regular oscillation. See fig. 10.

Swimming is not only a healthy and pleasant exercise, but a useful and beautiful art. It affords amusement during summer holidays at the sea-side or in districts where river, lake, or loch give opportunity. The effect it has on the nervous system is bracing and beneficial; it stimulates and strengthens the whole of the muscular tissues, gives full play to the lungs, under proper conditions promotes the acquirement of tone in the heart; while its tendency on the entire frame is to endue it with suppleness, symmetry, and grace. To any one in fair ordinary health swimming imparts delicious sensations of buoyancy, freedom, and power, besides keeping up the vitality wonderfully; but such as are weakly, anæmic, short in wind, or troubled in lungs or heart, and those in whom nervous fear usurps the place of common sense, should take swimming exercises, if they are undertaken at all, with great precaution—seldom, indeed, unless under medical prescription. A wise enjoyment of the refreshment of bathing,

Fig. 10.



moderately partaken of, must for a time at least suffice. To them swimming baths are much to be commended.

Swimming is, when thoroughly acquired, one of the most fascinating forms of physical exercise, and it is also one of the simplest, surest, and most powerful promoters of pure health. The robust find in it intensely pleasant recreation, and under the guidance of sanitary science the delicate will

* So Thomas Aird describes the rustic boy:—

"By day he thinks, by night
He dreams of swimming. Prone upon the sward,
Or snuglier lying in the clover field,
Sucking the honeyed flowers; even there, the pride
Of conscious power comes o'er him:—out he strikes
With hands and feet, unmindful how the grass
Or clover leaves green-stain his corduroys."

—*Frank Sylvan*, *Poetical Works*, p. 31.

find it a medicinal agency not lightly to be undervalued, if properly regulated and taken advantage of. Its main elements are easily learned and practised, whether the exercise is taken in sea or fresh water by floating, swimming, or diving.

Swimming is the progressive self-impelled motion of a living body through water. Man is unable to swim without learning to do so as an art. Most other animals swim by instinct. Owing to his peculiar structure and the narrow margin of difference between his specific gravity and that of water, man requires to apply his intelligence to his ability that he may swim. In reality the main points to be secured are—(1) the capacity of keeping the head above water, so that the breathing apparatus may have free play; and (2) that the arms and legs may be so trained that they shall act as oars and helm to propel and direct the body in its progress through the water, when education and exercise have made habit a second nature. As an educative art swimming has many claims to our attention; it quickens alertness of mind, adaptation of power to purpose, and cultivates courage and self-reliance. As an exercise it is an exhilarating and glorious excitement and delight. Its hygienic value rightly used is undoubted, as it brings cleanliness to the skin, fresh air to the lungs, healthy action to the limbs, reinvigoration to the heart, and generous stimulation to the entire frame. Of its usefulness we hear much—as a means of preserving our own life or the life of others when in accidental danger of drowning; but as a means of keeping up the ordinary vitality of the human system its utility is or ought to be truly enjoyable. It is, in fact, one of the every-day witnesses to the truth of Farrar's aphorism—"Physical work is a pure and noble thing; it is the salt of life, the girdle of manliness; it saves the body from effeminate languor, and the soul from polluting thoughts." In swimming, both pairs of the extremities are employed in effecting progress. The best idea of the motions required is to be had from watching a frog making its way through the water—unless you can get an expert to swim before you, meanwhile explaining and exemplifying to you the arm-stroke and the propelling movement of the legs and feet. Man's natural inability to swim is due to the construction of his frame. His head, in proportion to his body, is singularly heavy, owing to the larger quantity of bones, flesh, and brain compressed into its bulk, and the absence in it of such sinuses or cavities as, like air-bladders, lighten the heads of other animals. Persons having a good muscular development and somewhat inclined to fatness, are most likely to make good swimmers, because they displace a larger amount of fluid in relation to their weight. A lean and large-boned individual will be able to swim powerfully for a short distance; but as he will find difficulty in relieving himself by floating, his buoyancy is apt to lessen as he weakens with exertion. A large heavy head, small hands and feet, weak wrists are all more or less unfavourable to ease and speed.

Many instructors advise the use of artificial aids for keeping the learner afloat during the time he is engaged in the earlier exercises. These are intended to give him some support in the water, and some confidence while learning those initiatory strokes which when co-ordinated by practice impart power over the water. A row of corks fastened round the waist is one of the favourite suggestions; an air-belt tied round the chest just below the arms; a bladder suspended before the breast, hung from the neck and tied round the waist, are among the most common of these. Some teachers get their pupils to wear a waist-belt, in the middle of the back of which a ring is inserted to which a string is attached, and that again fastened to a stick to be used like a fishing rod for holding up the learner's body in the water and directing his progress; others affix the life-belt string to a sort of crane or trolley by which the learner is upheld, and so enabled to devote all his attention to the methodic mastery of the several strokes (1) singly, (2) successively, and (3) in combinations variously arranged. Confidence is a thing of slow growth with such appliances, and though, if necessary, we would not condemn their use and rather have swimming unlearned, yet we believe that a novice once thoroughly brought to feel that he is safe in the water, will learn more rapidly and enjoy more thoroughly the breasting of the billow. Ducking learners unexpectedly and leaving them to struggle, is a rough method of which we do not approve. We would encourage the trust of the learner by the knowledge gained by him.

It is always to be borne in mind that so long as the mouth and nose are really above the surface, however deep the water may be, the body will float. Nothing is more conducive to confidence while learning to swim than the knowledge of this fact, that water will support the human body so long as respiration is properly maintained. Salt water supports the frame better than fresh, and therefore the sea, when smooth and clear, is to be preferred to lake or river for beginners, if care is taken regarding the nature of the bottom, depth, and swell. To make the learner sure that the body naturally rises by floatage, and will maintain the power of floating while breathing is properly performed, should be one's first concern. It may be done thus—let a place be chosen where the bank slopes gently, has a firm bottom, and where the water is clear. Here the learner should wade in till breast deep, the water just touching the shoulder blades; then, turning his face to the bank, let him throw, as Dr. Franklin suggested, an egg halfway towards the shore. He knows that any forward movement he may make will take him into shallower water and nearer the land, so that at any time he may gain his feet and rise out of the water. He is then to draw a long breath—which makes the chest a self-contained air-bladder and float—and, with his eyes open, but his mouth shut, proceed to throw himself right into the water and try to catch the egg. Against his will he will find that the up-bearing power of the water prevents him, while keeping his hands under the water, from getting down to the egg, unless by using strong muscular force of arm and leg to resist being bobbed up again. When one rises after immersion he must first breathe out through the nostrils, to drive forth any water, before taking in breath by the mouth. Should he, by splash or scramble, feel as if he were out of his depth, he must keep his hands and arms under the water, tread the water, as if dancing through it, till he finds his feet, and then, unless his body is well up out of the water, he should slowly slide or glide his feet along the bottom, not attempting to walk, for if he do, on lifting one foot the water will probably take the other from beneath him, with a confusing effect.

The most suitable time for taking bathing or swimming as a health exercise or amusement is the early morning before breakfast. It is, however, advisable to take a glass of milk and a biscuit, or, if taste permit it, a raw egg, into which a pinch of pepper and a small teaspoonful of vinegar has been stirred, before going into the water. The next best time is in the forenoon, not less than an hour after breakfast—but not until the sun-rays have somewhat warmed and tempered the water. Those who take but a light breakfast—or are in the invalid list—had better defer their dip till after lunch, but ought not to delay it till the sea is getting cold and the air chill. No one should enter upon active swimming exercises when the stomach is full, or too empty, or when the energies are exhausted, or the body is chilled, or too hot. Do not enter the water in an over-heat or a state of perspiration—the reaction is too sudden and is often dangerous. It is true that the shock of immersion is one of sudden cold, and that the warmth of the sensation excited by a healthy reaction is wholesome and beneficial; but, if the body is suddenly chilled and the counteracting restorative reaction does not set in, the water should be left. If any one after his dip feels languid, inactive, headachy, constricted in the chest, shivery or chilled, the exercise either does not agree with him, or he has begun too hastily, or continued it too long. Unless one is able to swim briskly and disport himself actively, he ought not to be in the water more than half an hour. On coming out he ought to rub himself dry and ruddy with a rough towel. It may be well to know that friction applied to the limbs with a rough towel or flesh brush before entering the water is a good preservative against cramp, and to remember that one should as soon as possible, plunge over head in the water, and not wade about on the feet, letting the trunk cool.

It is not advisable that any one should go alone into the water to learn to swim. He should have with him a com-

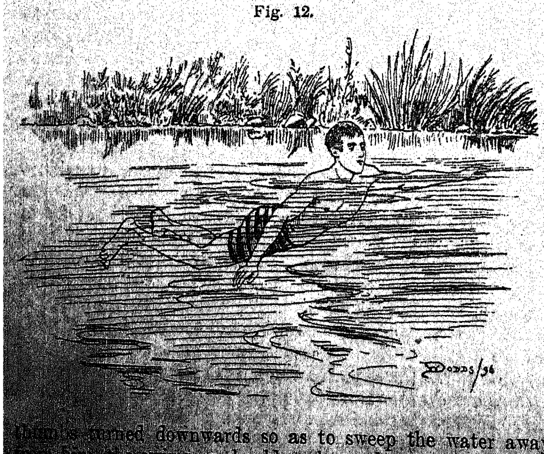
panion who is expert at swimming, who will be able to show and explain the movements to be made. Even then, however, it may be found the safer way for the tyro, till confidence is attained, to have tied round his waist a rope, about a third longer than the distance to which he wades, fastened at the front, that he may be able to be pulled to land by the holder of it, if need be, or to catch at it and pull himself in by it should he lose his confidence. It may afterwards, while exercising swimming, be a good thing to have one or two ropes fastened on land, but floating loosely in the water, within reach of those who are drilling or practising.

Supposing timidity overcome, the mastery of one's nerves and confidence in the sustaining power of water gained, we must learn the mechanical law on which swimming depends—namely, that every mechanical action is followed by a corresponding reaction in an opposite direction. The progress of the swimmer is brought about by the resistance of the water to the forces exerted in the backward strokes given by his arms and legs. Those strokes, which sustain and propel the body, are compound—that is, the actions of the arms and legs are to be simultaneous. The learner will only waste strength and staying power who splashes in the water with alternating strokes of hand and arm, of foot and leg. The sweep of the former imparts the up-bearing force which keeps the head above water, while the sweep of the latter comes only to destroy the advantage that ought to have been gained, gives a force that ducks the fore part of the body down, so

Fig. 11.

that the mouth gets filled with water, and spluttering, if nothing worse, ensues. The fore-stroke and the hinder-spurn must be taken at one instant, so that the effects of the former uphold the body, while those of the latter propel it. The fore-strokes ought not to be made on the surface of, but rather an inch or so under the water. The hands should be held scoop-like in shape, the fingers being close to the thumb, and the palm hollow, as one would form it if about to catch water in it from a flowing spring (as in fig. 11). With the hands so scooped, the

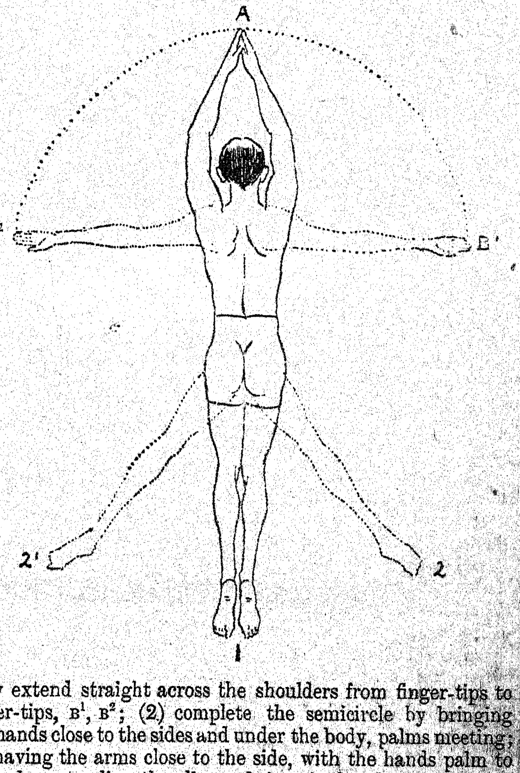
Fig. 12.



thumb is turned downwards so as to sweep the water away from him, the swimmer should make each arm, acting from the shoulder, sweep with its entire length from its extreme frontal range out from the body, and rounding it, bring itself to the close of the semicircular movement when all but touching the side; and at the very same instant, the knees having been drawn up beneath the body, yet as widely apart as possible, as they might be if crouching to make a spring, and the foot made hollow by crooking the toes under it, let the legs be thrown backwards with a vigorous push, so as to drive the heels as widely apart as possible when the movement has been completed. In this way the whole wedge of water which the legs enclose becomes the surface on which the swimmer can bring the percussive force of the inner and under parts of the thigh, as well as the propelling power of the well-curved soles of his feet. The larger the area acted upon, the greater is the advantage gained. When the legs have been pushed out to their full stretch, the feet should be brought together (as shown in fig. 12); this motion gives the forward impulse to the body, and when completed, makes less bulk to go through the water. The power of propulsion rests mostly with the legs and feet; the hands and arms, while also aiding the forward motion, are mainly of use in sustaining the body above the surface, and directing its course through the water. The strong, though not jerky or sudden, stroke of the legs has also the advantage of keeping the circulation active, and so lessening liability to cramp, which is often the effect of chill.

Let us now indicate the various elements of each stroke taken in breast-swimming in order. Having assumed the proper position, and being laid flat out, in the narrowest straight line we can form with our body, with our head well thrown back, and our hands extended beyond it as far as we can conveniently (as at A, fig. 13), let us proceed thus to exercise the *arms:* (1) make with each arm a quarter circle until

Fig. 13.



they extend straight across the shoulders from finger-tips to finger-tips, B^1, B^2; (2) complete the semicircle by bringing the hands close to the sides and under the body, palms meeting; (3) having the arms close to the side, with the hands palm to palm, by extending the elbows, bring the hands right up just under the chin; and (4) thrust the hands forth at length ready in position to repeat arm movement No. 1, &c. While this position of the arms is retained, make the following motions with the *legs*—(1) stretch out the legs in a straight line with the body, putting the feet together, as at 1; (2) draw up the knees underneath the body with legs and feet close; (3) thrust forth the legs as widely apart as possible and to their full extent, the feet being in such a position as to push fully against the water, as shown at 2 and 2^1; and (4) bring the